A.S. Yakovlev

FIFTY YEARS OF SOVIET AIRCRAF CONSTRUCTION

TRANSLATED FROM RUSSIAN

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The creation of a powerful aircraft industry, of a modern air force and a first-class civil aviation fleet, the development of aviation science and technology, these are some of the greatest historical achievements of the Communist Party, the Soviet state, the working class, and the scientific and technical intelligentsia, simply of all the Soviet people.

The victories in aviation, achieved by the Soviet Union, are of fundamental importance. They are the result of practicing the Leninist policy of industrialization which ensures that the USSR will be technically and economically independent of the capitalist world. They demonstrated the preponderance of the socialist economic system, its ability to liquidate the technical backwardness within the shortest possible time. They convincingly showed the sweep of the scientific and cultural revolution in the Soviet Union. They are a testimony to the incessant care by the Party and the nation to strengthen the defense potential of the country.

AUTHOR'S FOREWORD

This brief outline of the development of aircraft construction in the Soviet Union during the fifty years of Soviet power does not claim to be a comprehensive and profound analysis of the building up of the Soviet aircraft industry.

The author assumed a more limited task: to describe the main stages in the progress of aircraft construction by showing the technical growth of scientific and design thinking of Soviet designers from the October Revolution to the present.

The heritage of Czarist Russia was nothing except poverty. The Soviet people had to build the aircraft industry anew so that it would be worthy of a great country and correspond to military and economic needs. And such an industry was created!

The first Soviet airmen were surrounded by the understanding and care of V. I. Lenin, with his help aircraft factories were "put on their feet," and the Central Aerohydrodynamic Institute (TsAGI)*, the center of aviation science was organized, thus establishing Soviet air power.

The Central Committee of the Party and the Soviet government devoted systematic attention to the aircraft industry; they determined ways of developing Soviet aircraft production.

The successes of Soviet aircraft construction, which was most severely tested in World War II, are particularly pronounced when compared with the aviation of the Soviet Union's enemies and her allies in the last war. The preponderance is on the side of the Soviet Union, her armed forces and her scientific and technical thinking.

Talented designers and scientists, educated by the Party, founded Soviet aviation fame. Their successes are the visible result of the self-sacrificing work of a host of workers, administrative and technical employees of the aircraft industry who always marched in the foremost ranks of the fighters for the strengthening of the economic and defensive power of the Soviet Union.

Soviet aircraft construction passed through several major stages in its development. The first stage was the reconstruction of prerevolutionary plants and the preparation of aircraft production according to captured models. It corresponds to the period of restoration and reconstruction of the Soviet Union. The second stage was the creation of Soviet aircraft industry during the First and the beginning of the Second Five-Year Plan. Then aviation developed on the basis of original Soviet designs. The third stage was the mastering of new technology in the prewar years with a view to the lessons of the Spanish civil war. The fourth stage was World War II. The fifth stage was the technical revolution in aviation, connected with the advent of jet aircraft. Finally the present stage is the solution of problems

* [See List of Abbreviations.]

dictated by the military and defense needs and the rapid growth of Soviet civil aviation.

It is impossible in this brief outline to describe or mention all the diverse work done in each stage of development of aircraft construction and the work of all the design offices and individual designers who produced original types and kinds of aircraft, some of which were only of experimental interest but enriched our knowledge and others which at some time reached the production stage in small series but were withdrawn in favor of better aircraft.

Here we deal only with the main trends at each stage of aircraft construction development which were decisive for the creation of Soviet air power, corresponding to general political, military and economic tasks solved by the Party and government.

1. *A DIFFICULT START*

The Soviet state received a poor inheritance in aviation: some hundreds of old and worn-out airplanes, mostly of foreign-make and obsolete plants and worshops producing aircraft and engines, partly based on domestic labor. The aircraft industry had to be built from the beginning.

From the first days of Soviet power Lenin concentrated on the creation of a Red air fleet, and according to his instructions, TsAGI was founded in 1918 under the direction of Professor N. E. Joukowski.

In 1923 the Society of Friends of the Air Fleet (ODVF) was founded. This society not only accumulated means for the restoration of plants and the construction of aircraft, it also carried out much propaganda among the masses. The building of the country's aviation became a national task.

Before the revolution aircraft production in Russia was confined to about fifteen plants and workshops in Moscow, Petrograd, Simferopol, Taganrog, Rybinsk, Odessa, and Riga. The largest of them were: the bicycle plant Duks in Moscow, the Shchetinin and Lebedev plants and the Russo-Baltic Railroad Car Plant in Petrograd, and Anatra in Odessa. All the aircraft plants in Czarist Russia employed a combined total of about ten thousand workers of different trades.

At that time most of the planes built in Russia were of foreign-make, principally French Farmans, Morans, Voisins, Nieuports. Russian manufacturers were reluctant to accept orders for Russian-designed planes. Although Russia had planes of its own design, such as the Lebed, Parasol and Sikorskii, the tendency was to accept foreign types made according to drawings by Western firms or partly assembled from parts purchased abroad.

For instance, as early as 1913 the Russo-Baltic Railroad Car Plant built, under the direction of I. I. Sikorskii, the Il'ya Muromets* the first multi-engined heavy aircraft in the world.

During World War I the front received some tens of these planes. The designers constantly improved it, increasing its load capacity and range. Il'ya Muromets, E-type with four engines, had a speed of 135 kph and a ceiling of 4000 m. Its payload was 2.5 tons including a seven-man crew and 800 kg of bombs. Its defensive armament against enemy fighters, seven machine guns, was powerful at that time.

True, the designing of planes in Russia and in the West was primitive; aviation science was just being founded. The first branches of this science made themselves felt in the Moscow Technical College where an aviation circle worked under the direction of Professor Joukowski. Members of this circle were students of the college and are now famous Soviet aviation experts: Tupolev, Arkhangel'skii, Vetchinkin, Stechkin.

When war broke out in 1914, the Russian army of the front had just over two hundred fifty serviceable planes. The calculations of the Czarist government to cover their needs of aircraft and engines by purchases abroad

* This aircraft was built with the participation of N. N. Polikarpov who later became famous as a designer.

proved wrong. During the war great difficulties in supply were encountered. In addition the Allies tried to delude Russia with obsolete planes which were already unsuitable for their own armies. All this made it necessary to create a domestic aircraft industry.

It is characteristic that before World War I Russia produced, in total, approximately forty airplanes of different types per month whereas at the end of the war in 1917 the Duks plant in Moscow alone produced seventy-five to one hundred planes per month.

Duks produced exclusively landplanes. The Shchetinin plant in Petrograd, in addition to landplanes Nieuport, Farman, and Voisin, also produced flying boats designed just before the war by the famous Russian designer D. P. Grigorovich. Grigorovich's M-5 and M-9 flying boats were a great technical achievement for their time, and they served the Russian navy effectively in the Baltic and Black seas. Between 1914 and 1917 about two hundred hydroplanes were built. There were no such planes in other countries.

The work of the aircraft industry was impeded at that time by a profusion of different types and the frequent changes in design of aircraft by individual plants. During the war the plants introduced serial production of more than twenty different designs. In 1917 the main aircraft, produced in the largest quantities in Russian plants, were reconnaissance and bombing planes Farman-27, Farman-30, Voisin, and different types of the Nieuport fighter planes.

A particular difficulty for the Russian aircraft industry was the production of engines. A lack of good steels resulted in a weak metallurgical base, and there were other difficulties in the production of magnetos, spark plugs, and various instruments and devices. During the war only ten to fifteen percent of the required aircraft engines were supplied by Russian plants.

After the February revolution in Russia, from mid-1917, deliveries to the aircraft industry from abroad ceased almost completely. In October the fleet of aircraft had slightly exceeded one thousand machines, most of which were already in need of repair. There were considerable losses of planes at the front, and at that time aircraft had a short service life.

With the victory of the October revolution, under conditions of the incipient foreign intervention and civil war, the most important task became the defense and strengthening of the revolutionary achievements. Literally within the first few days of Soviet power the People's Commissariat of Defense created the Aviation Board with nine members (three military aviators and six from aircraft plants, trade unions and workers' organizations). The board was charged by the Soviet government to reorganize aviation matters and to collect from all fronts airplanes, engines and spare parts. It was necessary to gather as much as possible for the defense of the Soviet regime.

Under the existing conditions it was difficult to ensure production in aircraft factories. The representatives of the board therefore appealed to Lenin. This is what one member of the board, K. V. Akashev, wrote in his memoirs:

"... the representatives of the board turned to Vladimir Ilich Lenin. We asked the secretariat of the Council of People's Commissars to arrange for a personal meeting with Lenin, and were received that very same day. After having briefly outlined our views of the importance and place of the air fleet within the cultural structure of the Soviet republic, we asked Lenin

to create a People's Commissariat of the Air Fleet. Lenin did not object to assigning an important role to the air fleet under peacetime conditions of the country, and he agreed to its importance as one of the great cultural achievements of our century.

"This was particularly pleasing, because a short time before, when asked to retain the aircraft factories, Larin at the Presidium of the Supreme Economic Council replied that the Soviet state did not need enterprises 'similar to a scent and ointment factor'.

"Concerning the main problem that interested us, namely the creation of a People's Commissariat of the Air Fleet, Lenin did not reject it in principle, but he explained to us that in the present situation the Soviet state had a more urgent task than the thorough reorganization of the air fleet, namely that the October revolution must strengthen the foundation of the country, i.e., the economy.

"'Next time we shall discuss the creation of the People's Commissariat of the Air Fleet' were Lenin's own words in conclusion.

"Our meeting with Lenin took place in January 1918. At that time the situation was extremely serious. The Germans were threatening to conquer Petrograd, the Government was preparing to move to Moscow, in the south the counterrevolution took up arms... *"

The civil war and intervention made it imperative to develop chiefly the military air force. In May 1918 the Main Administration of the Workers' and Peasants' Red Air Fleet was created. In June the Council of People's Commissars issued a decree nationalizing the aircraft factories. It was the beginning of the recovery of the country's aircraft industry, with the Duks plant in Moscow and the Petersburg plant, subsequently named "Krasnyi letchik" (Red Flyer), being first.

That same year, 1918, under Lenin's direct participation, TsAGI was founded, later developing into a large center of aeronautical science of worldwide importance. It was the direct descendant of the aerodynamic laboratory of the Moscow Technical College and the Computing and Testing Office. This was one of the first proofs of the care with which the young Soviet state surrounded its aviation.

In December 1918 the board of TsAGI first met in Joukowski's apartment, under his chairmanship. One must visualize the atmosphere of those days. Many plants had closed down because of lack of raw materials; in Moscow there was no light and fuel. Yet the seventy-year-old Joukowski initiated and presided over a group for organizing a Soviet aviation center!

On Joukowski's initiative the Aviatekhnikum (in 1922 reorganized and called the Academy of the Air Fleet) was founded in Moscow. The mechanical department of the Moscow Technical College instituted aerodynamics as a field of specialization (on its basis the Moscow Aviation Institute (MAI) was founded in 1930).

Even under the conditions of economic collapse the aircraft plants and workshops gradually came back to life. There were no engines. Aircraft materials were beyond their original worth. In 1919, when the Caucasus was cut off from central Russia, a grave crisis erupted because of lack of aircraft fuel. The situation of the country in general was extremely grave. How bad the shortage of arms was is illustrated by the cable that Lenin

* Samolet, 1924, No. 2, p. 3.

sent to the Revolutionary Military Council on 9 June 1919, recommending that two or three men should share one rifle.* The supply situation became critical. Still under such conditions during the first years of Soviet power, in plants that had been preserved and partly rebuilt, aircraft were not only repaired but even built and sent to the war fronts.

After the counterrevolution had been defeated and the foreign interventionists chased out, the country was able to begin peaceful construction. The chief task was the rebuilding of the economy and defense of the state. It was necessary to ensure against any surprise on the part of the enemies surrounding the country.

One of the important defense measures was the creation of the country's own aviation. As early as January 1921 the Council of Labor and Defense decided to form a commission for developing a maximum program of aircraft construction. As the rebuilding of the economy progressed, the creation of aviation became literally a national concern. There were mottos: "Working men, build an air fleet!" "Proletarian, into the airplane!" "Donate an engine!" "Without victory in the air there is no victory on the ground!" "From model to glider, from glider to airplane!".

Three problems faced the Soviet Union: to find the means for building an air fleet and for equipping new aircraft plants; to build planes and teach the masters of the country, the workers and peasants to fly them; to open up the worst bottleneck in aircraft construction-engine production.

In March 1923 ODVF was founded. Its aim was to inspire a national movement for the building of an air fleet, to organize the collection of means for building aircraft and engines, to spread knowledge of aviation among the population. The Society promoted organizations of mass aircraft modeling and of glider flying. It made propaganda for aviation, published the journal "Samolet," organized propaganda flights throughout Moscow and the country, though still with Junkers planes bought abroad. The Society's newspapers and periodicals solicited donations for the building of the air fleet.

In 1923 the society Dobrolet was founded; it developed later into the Ministry of Civil Aviation.

The Soviet nation had to build its aviation while creating its science and industry and educating its own aeronautical scientists and engineers and workers and flyers. The nation knew that nobody else would help with these tasks, and it relied only on its own strength.

At first it was necessary to provide airplanes from abroad. To form regular air force units, a small number of Fokker-D7 fighter planes were bought in 1922-23 from Holland (where the German firm Fokker moved after the defeat of Imperial Germany), and English Martinside fighters, Italian Ansaldo reconnaissance planes, and German Ju-13 passenger planes.

The country did not even disdain using captured aircraft left behind by the interventionists. According to captured English models the Duks and Aviarabotnik plants in Moscow began producing the De Havilland-4, De Havilland-9, De Havilland-9A and the Krasnyi letchik plant in Petrograd produced the Avro-504.** Moreover, licenses were obtained for the

* Lenin, V.I. Polnoe sobranie sochinenii (Complete Collected Works), Vol. 35, p. 332.

** An Avro plane was shot down in 1919 near Petrozavodsk. The pilot was a White Guard by the name of Ankudinov. The famous aircraft designer Sergei Vladimirovich Ilyushin was then a mechanic on an aircraft repair train. Ilyushin was ordered to dismantle the plane after it had been shot down and to bring it to Moscow where drawings were made from it at the Duks plant.

production of foreign-makes. The Aviarabotnik plant made the Fokker-D11; Junkers in Moscow, which had a concession, produced the Ju-21 in Fil and assembled the Ju-13 passenger plane.

Copying foreign models was a necessary evil and a temporary measure. In the twenties Soviet aircraft design offices were already organized: under Tupolev in TsAGI and under Polikarpov and Grigorovich in the Duks plant. The first born of Soviet aircraft production were the light sports monoplane ANT-1 and the three-seater passenger monoplane AK-1, also called the "Latvian Gunner," which flew on the first Russian air route Moscow-Nizhnii Novogorod in 1924, and then took part in the flight from Moscow to Peking. N. N. Polikarpov built the single-seater I-1 fighter monoplane in 1923, and in 1924 flight tests began of the I-2 single-seater fighter designed by D. P. Grigorovich. In 1925 Tupolev built the all-metal two-seater ANT-3 (R-3) reconnaissance plane, and immediately afterward the twin-engined heavy bomber ANT-4 (TB-1).

Research work also branched into new fields. The aerodynamic laboratory of the Moscow Technical College became too small, and on 9 May 1924 a new aerodynamic laboratory was founded, now called the Chaplygin laboratory. Also laboratories for research on aircraft materials and engines, a towing basin, and an experimental plant were built.

All these measures by the Soviet state for building its own aviation required an enormous effort and large sums of money. It received much help from the ODVF. The problem of building an air fleet and the work of the ODVF were discussed by the 13th Congress of the Bolshevik party. On 1 June 1924, ODVF, in a ceremony at the Moscow central airport, presented the 13th Party Congress with the "Lenin" squadron.

From money donated by the population one hundred combat aircraft were built and delivered to the air force. At that time money was also collected for the squadron "Ultimatum" in reply to the sudden ultimatum delivered by Lord Curzon to the Soviet government, for the squadron "Our Reply to Chamberlain," and others.

The ODVF organized a number of long flights. In 1923 Velling in a Ju-13 plane flew 11,000 km of the route Moscow-Tiflis-Tashkent-Moscow. In 1924 six R-1 planes piloted by Mezheraup, Garanin, Arvatov, Goppe, Yakobson and Zalevskii, flew to Kabul in Afghanistan. These planes of Soviet manufacture traversed the Hindukush mountain range and attained an altitude of 5000 m. In 1925 Kopylov in a Ju-13 plane flew the route Moscow-Kazan-Ufa-Perm-Vyatka-Ustyug-Vologda-Moscow, a total of 10,000 km. That same year the flight from Moscow to Peking, for that time a grandiose undertaking, took place. There were six planes, of which three were Soviet manufactured (types R-1 and R-2), one was an AK-1 passenger plane and two Ju-13s. Because of the variety of planes and the difficulty of the route, this flight was a serious challenge to pilots and machines. The expedition reached Peking after thirty-three days. The participants of the flight, Gromov, Volkovoinov, Ekatov, Naidenov, Tomashevskii and Polyakov, received the title "Distinguished Flyer."

Beginning in 1925 the organization of flights was taken over by the Commission for Long-Range Soviet Flights, which was headed by S. S. Kamenev, the commander-in-chief.

In the summer of 1926 two international flights took place with R-1 planes: the first piloted by Ya. Moiseev on the route Moscow-Teheran-Moscow, more

than 6000 km and the second piloted by P. Mezheraup, on the route Moscow-Ankara, approximately 2000 km. From then on all the flights were made on planes which were not only made but also designed in Russia.

Aircraft construction developed both in quantity and in quality. From planes whose main materials were pinewood, plywood and canvas, the Soviet industry managed as early as in the mid-twenties to change over Tupolev's all-metal dural planes. A. N. Tupolev at that time wrote about the first Soviet metal plane, the ANT-2.

"The 26 May 1924 should be marked in the history of Soviet aircraft construction. On that day, over the central airport, the first Soviet metal plane, designed and built by the Central Aerohydrodynamic Institute of the Scientific and Technical Section of the Supreme Economic Council, carried out its test flight...

"... The plane was built by a commission for the construction of metal planes consisting of the members: Chairman A. N. Tupolev, the author of the design and generally in charge of the work of the commission; Deputy Chairman I. I. Sidorin, who worked out methods of thermal treatment and processing of the material and carried out strength tests; scientists I. I. Pogoskii and G. A. Ozerov.

"Elaboration of methods of analysis, assortment of parts, shapes and design details of the planes, testing and direct supervision of production were in the hands of TsAGI engineers A. I. Putilov, V. M. Petlyakov, I. I. Pogoskii, B. M. Kondorskii, N. S. Nekrasov, N. I. Petrov, E. I. Pogoskii, A. I. Zimin and others.

"The test flight was performed on 26 May by TsAGI engineer N. I. Petrov, with sand for ballast. The flight was not experimental, therefore it was not timed; its aim was to find out the main flight characteristics of the plane.

"The plane took off three times altogether and accomplished five or six circles at an altitude of up to 500 m. Both by its behavior in the air and by its speed the machine proved its worth, and in the opinion of the many onlookers it is a valuable contribution to Soviet aircraft construction."*

The ANT-2 is the first-born among the Russian all-metal planes. In spring 1926 the first official tests were concluded of the first combat plane designed by A. N. Tupolev. This was the ANT-3, or R-3, an all-metal two-seater reconnaissance biplane, provided in serial production with a 400 hp, M-5 engine.

In 1926 M. Gromov as the pilot and E. Rodzevich as the flight engineer, in a R-3 plane called Proletarii carried out a flight which at that time was an outstanding feat. They started from Moscow on 31 August and returned on 2 September, having flown the route Moscow-Königsberg-Berlin-Paris-Rome-Vienna-Warsaw-Moscow, i.e., 7000 km in 34 hours flying time. On that flight the plane had a cruising speed of 200 kph. Gromov's flight caused a sensation in Europe.

In August 1927, also in a R-3 plane, named Our Reply, Shestakov as the pilot, with flight engineer Fufaev, flew the route Moscow-Tokyo-Moscow, about 22,000 km, in 153 hours flying time. This was an outstanding achievement and characterized not only the high level of the builders of aircraft and engines, but also the culture of production which ensured a high degree of

*Samolet No. 8, p. 12, 1924.

reliability in the operation of all parts of the aircraft and engines and the skill of the country's pilots.

Gromov with a group of correspondents of Moscow newspapers carried out a flight in 1929 in a three-engined ANT-9, seating ten persons, visiting the capitals of European countries, landing in Berlin, Paris, Rome, London and Warsaw. The length of this flight was 9000 km, average speed was 180 kph. The entire Soviet and world press gave the highest praise for plane and pilot. After that the plane was put into serial production. For several years it was used on the routes of the Civil Air Fleet.

A triumph of Soviet aviation was the flight of pilots Shestakov and Bolotov, navigator Sterligov, and engineer Fufaev in a metal airplane ANT-4, called Soviet Land, from Moscow to New York in the fall of 1929. Although this flight took more than a month because out of a total length of the route of 21,500 km, 8000 km were over the ocean and much time was spent on replacing the wheel-type landing gear by floats, this was the first flight of Soviet flyers in a Soviet plane with a Soviet engine to America. Thus it was an outstanding achievement.

The flights of Soviet aviators in various planes of Soviet manufacture were a stringent test, and they proved that Soviet technical thinking and production know-how did not lag behind the West.

Now emerged the problem of selecting for mass production those planes and engines of Soviet design which had withstood the tests. This was very important for defense. In 1927 in its appeal "To all organizations of the VKP(b), to all workers and peasants" the Central Committee of the Party said: "It is necessary to improve socialist industry, raise productivity of labor, resolutely carry out socialist rationalization of production, improve agriculture, improve and strengthen transport, it is necessary to raise and develop the military industry for the defense of the country..."* Among the keynotes to the "Defense Sunday," organized in 1927, the Central Committee of the Party included the appeals:

"Let us build up the military industry! We will give entire units of planes and tanks! We will raise the output of rifles and machine guns! The Soviet land must become an impregnable fortress!"

"Workers and peasants! Join the ranks of Osoaviakhim! Help defend the Soviet Union in an organized manner!"**

Toward the end of the twenties conditions were favorable for the broad development of the production of airplanes, engines, instruments, and of new aircraft materials. The problem of building a powerful aircraft industry had to be solved in all its ramifications. It was solved in the years of the First Five-Year Plan.

* KPSS o vooruzhennykh silakh Sovetskogo Soyuza (The CPSU on the Armed Forces of the Soviet Union).— Moskva), Gospolitizdat, p. 295. 1958.

** Ibid, p. 297.

2. *SOVIET PLANES, SOVIET ENGINES*

In the years of the prewar five-year plans a powerful aircraft industry was created in the Soviet Union thanks to the unstinting efforts of the Party, the government and all the people. The Red Air Fleet was completely equipped with Soviet-made machines. Modern plants were built, research institutes and design offices were organized, and scientists, designers and aviation specialists were trained. On the basis of modern science and technology new types of fighter, attack and bomber aircraft were developed and put into serial production in the early forties. The war found the aircraft industry engaged in developing mass production of modern types.

Although at the beginning of the First Five-Year Plan the Soviet aircraft industry had already completely abandoned the copying of captured planes and production under license, and had changed over to the production of Russian aircraft, engines and instruments, the chief task in the Five-Year Plan was improvement and preparation of mass production.

In June 1929 in its resolution "On the state of defense of the USSR" the Central Committee of the Party noted: "It must be conceded that one of the most important results of the past five years is the creation of a Red air fleet. An important task in the coming years in building up the Red aviation will be a rapid improvement of its quality to the level of the most advanced bourgeois countries, and every effort must be made to plant the seeds, cultivate and develop our own, Soviet scientific and design cadres, especially in engine construction."*

Under these circumstances it was found that the Five-Year Plan of Economic Development provided favorable conditions for considerably increasing the defense potential of the USSR. During the previous five years firm organizational foundations of the army were laid; now the most urgent task was the creation of a modern base of military technology. The Central Committee of the Party found it correct and timely "to develop on a broad front the work of strengthening and improving the technical equipment of the army."**

At the beginning of the First Five-Year Plan both design centers of the country were considerably strengthened: TsAGI, which was headed by A. N. Tupolev, and the Design Bureau headed by N. N. Polikarpov. In the early thirties Tupolev's design office was removed from TsAGI and established as an independent experimental and design organization. TsAGI continued with scientific research while Tupolev's design office worked out new types of aircraft. Tupolev attracted and trained an entire group of scientists: A. A. Arkhangel'skii, V. M. Myasishchev, V. M. Petlyakov, A. I. Putilov, P. O. Sukhoi and others. Later on they themselves developed and designed new types of aircraft.

* KPSS o vooruzhennykh silakh Sovetskogo Soyuza (The CPSU on the Armed Forces of the Soviet Union), p. 320.

** Ibid., p. 319.

Tupolev's design office specialized in building multiengined dural bombers and passenger planes.

Polikarpov's office designed new fighter models. Approximately for ten years Soviet fighter units were equipped almost exclusively with his machines.

In addition to the powerful offices headed by Tupolev and Polikarpov there were also smaller design offices. A team headed by D. P. Grigorovich worked on types of engines suitable for fighters. Some of them, e.g., I-2 and I-2B, were produced in small quantities during the late twenties. In the Ukraine K. A. Kalinin designed and supervised construction of the K-5 passenger plane. A. S. Yakovlev's design office worked on low-powered planes. Production of the following engines also was introduced: M-22, radial, air-cooled, 480 hp and M-17, water-cooled, 500 hp.

By 1930 the basic types of aircraft and aircraft engines had been tested in operation and were being produced in Soviet plants from Soviet materials by the hands of Soviet workers and technicians. The army air force received small numbers of I-3 fighter planes and R-5 reconnaissance planes, designed by Polikarpov, and TB-1 bombers, designed by Tupolev. Prototypes of new and improved types of combat aircraft were being prepared for serial production.

One of the first Soviet fighters, the I-3, a wooden biplane, was built as early as 1927. With a M-17 engine it developed a speed of 280 kph. Its armament consisted of two machine guns. Altogether four hundred planes of this type were produced. The I-5, produced in 1930, was a further development of the biplane. It was a light, maneuverable fighter powered by a M-22 engine, with a speed of 286 kph. It was also armed with two machine guns. The I-5 was produced in larger numbers, about eight hundred.

Polikarpov's outstanding design, the two-seater R-5 reconnaissance plane, powered by a M-17 engine, was widely used by the army air force. This wooden biplane with fabric wing covering and plywood fuselage skin proved exceptionally successful. For its time it had an excellent maximum speed, 230 kph. The wings were connected by N-shaped streamlined struts and steel bracing. The upper wing was fixed to the wing center section, mounted on the fuselage by two pairs of drop-shaped, cross sectioned struts. The aerodynamically refined shape reduced resistance, yielding excellent mechanical and flying characteristics.

The R-5 was an outstanding combination of adaptability to fulfill tactical tasks, reliability and technological design, good stability and dirigibility, simplicity of piloting and operation. Flight tests of the R-5 began in 1928, and in 1931 serial production of the plane began. Within six years about seven thousand planes of different versions were built. The Soviet air force received a splendid reconnaissance plane which had no equal anywhere in the world. In September 1930 a group of R-5 planes excelled in carrying out a flight on the route Moscow-Ankara-Tbilisi-Teheran-Termez-Kabul-Tashkent-Orenburg-Moscow. The distance of 10,500 km was covered in 61 hours 30 minutes flying time, at an average speed of 171 kph.

At that time the Iranian government issued an international tender for reconnaissance aircraft for the Iranian air force. In competition flights the R-5 won first place, outstripping the best British, French, and Dutch aircraft. The R-5 was widely used in military and civil aviation for many years, including those of World War II. After having flown for a long time

and having been used for various purposes, the plane was eventually superseded by another excellent aircraft designed by Polikarpov, the U-2 (Po-2). The basic version of the R-5 as reconnaissance plane or light bomber carried three machine guns and could take on 500 kg of bombs. Other military versions were the sea reconnaissance plane fitted with floats, the R-5Sh attack plane with seven machine guns and the modernized version with covered cockpit, the R-Z. Civil aviation used widely the P-5 and P-5a mail and passenger versions. In 1934 R-5 planes participated in saving the members of the Chelyuskin expedition. The pilots in their two-seaters took off from the ice with five of six passengers on board.

In 1925 Tupolev's plane TB-1 (ANT-4) underwent tests; this was the first Soviet-built heavy bomber and one of the largest planes built in the twenties. The overall design of this plane was a veritable revelation to world aviation. The TB-1 was an all-metal monoplane powered by two M-17 water-cooled, wind-mounted engines. The main innovations were the cantilever wing with five spars and corrugated dural covering and its thick profile. Analysist and design of the wing were the work of V. M. Petlyakov who succeeded in ensuring high strength and rigidity of that large wing whose span was 28.7 m. The low wings made it possible to employ a comparatively small landing gear with wide track. By filling the thick wing with a large amount of fuel, the designers endowed the aircraft with outstanding load capacity and range. With a maximum take-off weight of about 7.8 tons, the TB-1 could carry a payload of 3.5 tons. The normal weight of bombs was 1000 kg and the range was then 1350 km. The plane had a good speed, 200 kph. It carried a crew of four and its defensive armament consisted of four machine guns. The TB-1 was the first plane to be fitted with boosters, which considerably reduced the take-off distance and facilitated lift-off of the overloaded aircraft. Between 1928 and 1932 the TB-1 was series-produced in land and seaplane versions. It marked the beginning of a new era in the development of heavy aircraft and is considered as the first genuine bomber. Similarly, all heavy, nonmaneuverable aircraft (bombers and transport planes) were built as monoplanes with cantilever wings.

A logical development from the design of the TB-1 was the gigantic bomber type TB-3 (ANT-6), first built in 1930 and series-produced from 1932 to 1937. This plane was a four-engined, cantilever-winged monoplane. The four engines (first M-17, then M-34) were mounted on console trusses on the leading edge of the wings, two on each side of the fuselage. The wings, fuselage and tail unit were made from duralumin; the fixed landing gear, engine trusses and other parts from steel; the outer covering of the entire aircraft was, as before, corrugated duralumin. Compared with the TB-1, the wing span was almost half as large, attaining the enormous magnitude of 40.5 m, and the wing area was doubled to 230 m^2. During development and production Tupolev improved the design of the aircraft and increased the engine power. He thereby succeeded in raising the take-off weight of the TB-3 to 19—21 tons and the speed to 288 kph, each engine providing 970 hp. The TB-3 could carry 5 tons of bombs. With a bomb load of 2 tons the TB-3 had a range of almost 2500 km. It had a crew of eight, its defensive armament was eight machine guns.

During the mid-thirties the USSR was the only country mass producing such huge aircraft as the TB-3. Tupolev himself supervised the preparations for production, having been nominated chief engineer of the administration

of the aircraft industry of the People's Commissariat of Heavy Industry.

The TB-1 and TB-3 had a decisive influence on the further development of bomber aircraft, both in the Soviet Union and abroad, especially in the United States. These bombers blazed the trail for building heavy landplanes and they predetermined for many years the most rational configuration. In the ten years preceding the war the Soviet bomber force was supplied with 216 TB-1 and 818 TB-3 planes. They were also used in civil aviation as transport planes (G-1 and G-2) for heavy and bulky loads, especially their arctic version. In an ANT-4 pilot A. V. Lyapidevskii rescued the first group of the Chelyuskin crew in 1934. In 1937 I. D. Papanin's expedition to the North Pole took place in four ANT-6 planes.

Mass production of aircraft required the production base to be enlarged and new, large aircraft plants to be built; the Central Committee of the Party therefore adopted a resolution on the building of large aircraft, engine and instrument plants. By 1933 these plants, which had been started at the beginning of the First Five-Year Plan, already supplied aircraft in large numbers: the I-5 fighter, the R-5 reconnaissance plane, and the TB-3 bomber.

The aircraft industry grew out of the industrial base of the country, assimilating its foremost achievements, mainly in the fields of ferrous and nonferrous metallurgy, radio and electrical engineering, mechanical engineering, instrument manufacture, and chemistry. The qualitative and quantitative level of aviation at that time was therefore a lucid reflection of the growth of the entire national economy.

The country, however, could not rest satisfied with its achievements. The resolution of the 16th Party Congress noted with satisfaction the heightened fighting efficiency of the Red Army. On the other hand the congress pointed emphatically to "the necessity of concentrating the Party's attention on an even greater mobilization of all the forces of the working class and the mass of small and medium peasants upon strengthening the defense potential of the USSR, the power and fighting efficiency of the Red Army, Navy and Air Force."*

The further strengthening of the defense potential of the country required even greater activity of the broadest masses of workers. The resolution of the Central Committee "Ten Years of Defense" said that it is essential "to turn the attention of the working people to the problems of building civil aviation, airship construction, mechanization and motorization of the Workers' and Peasants' Red Army," and to "strengthening the organization of Osoaviakhim (cadres, growth, material base, etc.)."**

The necessity of constantly improving aviation techniques required a broad development of scientific research in aviation. TsAGI, where research on aerodynamics, aviation materials, and aircraft engines was carried out, was a universal scientific organization in its field, and it became necessary to split it up into independent specialized research institutes. In addition to the Special Design Bureau under chief designer Tupolev, two other departments also left TsAGI and became independent. The department of aviation materials became the All-Union Insitute of

* KPSS o vooruzhennykh silakh Sovetskogo Soyuza (The CPSU on the Armed Forces of the Soviet Union), p. 322.

** Ibid., p. 328.

Aviation Materials (VIAM) and the aircraft engine department became the Central Institute of Aircraft Engine Construction (TsIAM). Within an exceedingly short time these organizations attained a high scientific level.

The question of personnel was of decisive importance for the plants, institutes and all other institutions of the aircraft industry. There was a shortage of prerevolutionary specialists as well as of young graduates of the Military Aviation Academy. Most graduates of the academy joined the flight units of the air force. In 1930 MAI was founded. Within a short time it became one of the best institutions of higher learning in the country; it trained aviation engineers for the most diversified fields.

When summing up the results of the First Five-Year Plan, the Party proudly noted the success achieved in the building of the aircraft industry. The resolution of the joint session of the Central Committee and the Central Control Commission of 10 January 1933 mentioned among the gigantic engineering works the aircraft and aircraft engine plants in Moscow, Gorki, Voronezh, Siberia.* The resolution of the 17th Party Congress (January—February 1934) counted the building of aircraft and aircraft engine plants, one of the new branches of production, as one of the particularly great successes of industry.** As a result aviation was able to develop further quantitatively and qualitatively.

During the Second Five-Year Plan (1933—37) the aircraft industry acquired all the necessary scientific know-how, based on highly trained personnel and powerful production which increased in size every year as new plants were built. Aircraft plants were planned by a special project institute which had been organized within the framework of the aircraft industry.

Wherever it was possible, production of aircraft and engines was organized in flow lines and on conveyor belts. Pressing and casting of parts were introduced on a large scale. This led to a considerable increase in the productivity of labor and output. Simultaneously, owing to the achievements of the research institutes and design offices, the flight and tactical characteristics of the aircraft were also greatly improved.

Until the mid-thirties the USSR developed both heavy, nonmaneuverable monoplanes with fixed landing gear and corrugated skin (bombers TB-1, TB-3, and passenger planes) and light maneuverable biplanes (fighters and reconnaissance planes). In the middle thirties a decisive and final changeover from biplanes to monoplanes took place. This was because of the achievements of aerodynamics, mechanics and engine construction, accurate methods of stress analysis, and the introduction of new high-strength materials. For some time maneuverable biplanes still existed in the fighter force together with fast monoplanes, but by the end of the thirties the only biplanes built were the U-2 training planes.

The changeover to monoplanes with cantilever wings was an important stage in the technical progress of aircraft construction. The monoplane is aerodynamically superior to the biplane, but at flying speeds of 200 kph—250 kph this advantage is small. Further the sufficiently rigid and strong

* KPSS v rezolyutsiyakh i resheniyakh s"ezdov, konferentsii i plenumov TsK (The CPSU in Resolutions and Decisions of Congresses, Conferences, and Plenary Session), Part II, p. 719. Moskva, Gospolitizdat. 1953.

** Ibid., p. 745.

airfoils in the form of the biplane cell have a small span and are simple in production. As flying speed increased, the aerodynamic advantages of the monoplane became more predominant, and new aircraft were built increasingly as monoplanes. At first monoplanes were provided with bracing or inclined struts, taking some stress off the wings; but bracing and inclined struts, placed in the air stream, caused considerable head resistance. As stress analysis was perfected and experience in design was gained, fast monoplanes with cantilever wings were built, where the wings had no outer supports.

An important factor was the increased wing loading: $140\,kg/m^2$—$170\,kg/m^2$ instead of $70\,kg/m^2$—$100\,kg/m^2$ in monoplanes around 1930. Although leading speed, take-off distance and landing distance have increased greatly, a serious deterioration in take-off and landing characteristics was averted by the introduction of brake wheels and high-lift devices (flaps and slats).

Flying speed was increased by reduced relative wing thickness and the application of biconvex profiles; streamlined fuselages and closed cockpits; fillets to reduce the deleterious interference at the joint of wings and fuselage; use of smooth, thick wing covering (plywood or metal) instead of the thin corrugated covering on heavy planes and fabric covering on light planes. By countersunk riveting, the use of sheet butt joints, the polishing of the covering, the aerodynamic friction drag was greatly reduced.

One of the most important achievements of aerodynamics was the solution of the problem of retracting the landing gear in flight. The resistance of a fixed landing gear represents twenty to twenty-five percent of the total resistance of the aircraft. The designers therefore endeavored to retract the landing gear completely or partly in flight, even at the price of a certain increase in the weight of the aircraft (by one to two percent and a more complicated design. This problem was practically solved in 1935—36. The first stage was a fixed cantilever landing gear with spats (reducing the drag of the landing gear by about thirty percent), then the main struts were retracted, and finally also the tail wheel which replaced the skid. A fully retractable landing gear meant an increase of fifteen to twenty percent in maximum flying speed without increasing engine power.

Flying speed was also increased by the introduction of cowling for engines and radiators. On air-cooled engines where the cylinder heads protrude into the air stream they were covered with narrow profiled streamlined rings (Townend rings), which reduced drag. Then special cowls were designed which reduced drag even more.

On liquid-cooled engines the nose radiators, which were situated immovably in the air stream, were replaced by sliding radiators whose area could be reduced with increasing flying speed when the cooling action became more intensive. The next step was ducted radiators, with the ducts located in the wings, the fuselage, or the engine nacelle.

All these measures reduced drag by one-third to one-half. Flying speed increased by twenty to thirty percent with engines of equal power.

The appearance of controllable-pitch propellers also meant a qualitative improvement in aircraft construction. The fixed-pitch propellers, used until the thirties, were designed for some definite flying conditions. Under different flying conditions the efficiency of the propeller was reduced. At

flying speeds of 200 kph — 250 kph the losses were small, but with increasing speeds the difference between maximum and take-off speed increased, and this caused a considerable increase in loss of thrust of the power plant.

The first solution was a two-pitch propeller whose blades could be adjusted to a small pitch for take-off and climbing and to a large pitch for maximum flying speed. Then appeared propellers with continuously adjustable pitch, controlled by a special lever, and finally automatic propellers whose blades are automatically adjusted such that the engine runs at the most advantageous speed all the time. Although controllable-pitch propellers are considerably heavier and more complicated than fixed-pitch propellers, they were used in high-speed aircraft because maximum speed increased by seven to ten percent, the ceiling by eighteen to twenty percent, take-off thrust by forty to forty-five percent, and range and rate of climb also increased.

Technical progress of aviation was bound up with the increase in maximum-power altitude and engine power. The power of piston engines is greatly reduced at extreme altitudes, because the density of the air is reduced. Engines were therefore provided with single-stage or two-stage superchargers, increasing the pressure of atmospheric air before it entered the cylinders. Thus it was possible to maintain engine power up to the rated altitude. Supercharged engines also raised the maximum flying speed. Further, the possibility of engaging the supercharger low above the ground made it possible to boost the engine for a short time in case of need (difficult take-off conditions, aerial combat at low altitude).

During the late thirties engine power was rapidly increased, together with a reduction in the specific weight of the engines. The power of series-produced engines rose from 700 hp or 800 hp to 2000 hp and the specific weight dropped from 0.9 kg/hp to less than 0.5 kg/hp, i.e., almost by one-half. At the same time considerable success was achieved in reducing the specific dimensions of the engines. All this contributed to increased speed, ceiling and range of Soviet aircraft.

The motto of the Soviet government to "fly highest, furthest and fastest" met with an enthusiastic response from scientists, designers and employees of the aircraft industry.

New aircraft constantly appeared on the experimental airfields: I-15, I-16, SB, DB-3, ANT-25 and other outstanding machines with which the Soviet aviators ensured a number of the highest aerial achievements for the Soviet Union.

In 1933 — 34 Polikarpov designed and constructed a maneuverable biplane fighter, the I-15, with maximum speed of 360 kph, and a monoplane fighter I-16 with retractable landing gear, having a maximum speed of 454 kph. Both planes were powered by a air-cooled radial M-25 engine, 715 hp, with a well-designed cowling and controllable-pitch propeller. The aircraft was of mixed design, typically Polikarpov: wood, steel pipes, canvas skin, and in limited amounts duralumin. For the first time there was armor plating behind the pilot. The armament consisted of two synchronized 7.62 mm machine guns.

The I-15 and I-16 appeared almost simultaneously and were also simultaneously in action. At that time it was believed that because of their insufficient horizontal maneuverability, monoplanes would have to operate together with biplanes. The former would catch up with the enemy and paralyze his actions while the latter would destroy him. This concept

was maintained until it was put to the practical test in Spain and on the Khalkhin-Gol, where it was found how difficult it is to organize the cooperation of fighters of different types under the rapidly changing conditions of aerial combat. In 1940 new high-speed monoplanes with powerful engines appeared: Yak-1, MiG-1, and LaGG-3; they were much superior to the best biplanes in speed and vertical maneuverability, making the rejection of biplanes final. Between 1934 and 1939, however, the I-15 and I-16, of which 6519 and 6555 machines (in different versions), respectively, had been built, represented the strength of the Soviet air force. They both underwent a long development and were excellent fighter planes.

The I-15 had outstanding maneuverability. The time needed to execute a turn at 1000 m was eight seconds, which was a record for fighters. The plane required six minutes to climb to 5000 m and the service ceiling was more than 9000 m. Regarding flight and technical specifications, especially vertical speed and horizontal maneuvers, the I-15 was better than comparable types abroad. It was considered the best biplane fighter. In November 1935 V. K. Kokkinaki broke the world record when he attained an alitude of 14,575 m with a lightened I-15.

In the construction of the I-15 new materials were used, such as chrome-molybdenum pipes and sheet electron. This ensured a comparatively low weight of the aircraft while the strength remained sufficient.

The design of this plane offered great possibilities for further development. In 1936 the I-15 bis with a maximum speed of 370 kph made its appearance. It was fitted with four synchronized machine guns, and unlike the I-15 its upper wing was straight. In 1938 the I-15 Z was built; it had incipient gull wings (and was later known as Chaika (gull)), and with its M-62 engine it attained 443 kph. Although it was a biplane, the aircraft excelled because of its streamlined shape and retractable landing gear. It proved its worth on the Khalkhin-Gol, where for the first time in addition to the four machine guns rocket missiles were also used. The I-15 Z was the only series-produced Soviet biplane with retractable landing gear, and it was the best biplane fighter ever built.

The I-16 developed similarly. Polikarpov did not like "transporting air," so he designed an original plane with minimum dimensions and low flying weight, 1422 kg. The I-16 was characterized by a sturdy fuselage of circular cross section, "trimmed" in front, and small low wings. The plane had a wingspan of 9 m and was in total 6 m long. The dimensions and shape of the plane remained unchanged for years of development, only in the last series was the cockpit fitted with a movable canopy. The I-16 was the first high-speed monoplane with retractable landing gear and a controllable-pitch propeller accepted by the Soviet air force. With a M-25 engine its speed was 170 kph greater than the speed of the I-5 and 90 kph greater than the speed of its contemporary maneuverable biplane, the I-15. Its speed also exceeded the speed of contemporary fighter planes in other countries. In the subsequent years the power of the engines, fitted in the I-16, was gradually increased up to 1000 hp and the maximum speed of the plane to 525 kph. New series with more powerful armament were produced. The attack plane version of the I-16 could carry up to 200 kg of bombs, and its armor-plating was reinforced. After four or five years of development, however, the take-off weight and wing loading increased by about thirty percent somewhat reducing the plane's maneuverability. A shortcoming of

the I-16 was its small reserve of static stability, making the plane difficult to control and requiring highly skilled pilots. Nevertheless in the first year of World War II the Soviet airmen flying I-16 planes self-sacrificingly took on Messerschmitts which had a superior speed.

Many famous airmen began their careers in I-16's, in Spain, in Mongolia, at the fronts in World War II. Among them are G. P. Kravchenko, twice recipient of the Hero of the Soviet Union, B. F. Safonov, and A. V. Vorozheikhin.

The first series-produced Soviet frontline bomber was the SB, designed and constructed in 1934 by Tupolev. It had two M-100 engines of 860 hp each, was completely made of duralumin, with smooth covering, unlike the earlier Tupolev planes which had corrugated skin. Maximum speed of the SB was 420 kph, range 1000 km, bomb load 500 kg, and it carried a crew of three.

Only a year after the SB the high-speed, long-range bomber DB-3, designed by S. V. Ilyushin, made its appearance; it was powered by two air-cooled M-85 engines.

The DB-3 was an all-metal plane, with a streamlined fuselage, a monocoque of oval cross section, at the rear smoothly blending into the keel, in front into a semisphere. The two-spar cantilever wing had a smooth dural skin. Inside the wings there were large fuel tanks, and the weight of the fuel reached as much as twenty-seven percent of the flying weight. The plane had a crew of three and its armament was three machine guns. The DB-3 became the main Soviet long-range bomber, flying successfully throughout World War II, renamed the Il-4; however, the Il-4 clearly differed from the DB-3. Instead of M-85 engines of 765 hp each it was fitted with M-88B engines of 1100 hp, and its speed increased from 320 kph to 445 kph. For the same distance, 4000 km, the Il-4 could take on 1000 kg of bombs, i.e., twice as much as the DB-3, its take-off weight increased somewhat, reaching 10 tons, and wing loading was increased from 140 kg/m^2 to 150 kg/m^2. Early in World War II, when there were difficulties in the supply of metal, the designers succeeded in replacing some of the metal assemblies of the Il-4 with wooden ones without harming the flight performance. The Il-4 was better in every respect, especially in range, than its counterpart, the German HE-111 bomber which had a range of 2300 km.

In total 6784 planes, type DB-3 and Il-4, were built. Before the war V. K. Kokkinaki established several outstanding height records in a DB-3, exceeding with a load of 500 kg and 1000 kg 12 km, and with a load of 2000 kg 11 km. He also carried out several long flights, the most famous of which was his flight to the United States, a distance of 8000 km. Il-4 bombers were the first to raid Berlin in August 1941.

In 1932 Tupolev's design office began work on the ANT-25 (or RD) which later, in the summer of 1937, gained world renown when Chkalov, Baidukov and Belyakov flew nonstop from Moscow to the United States, covering a distance of more than 9000 km in 63 hours flying time. The fame of the RD aircraft was enhanced by Gromov, Yumashev and Danilin, who a month later repeated this feat but covered more than 11,000 km in 62 hours flying time. The success of the flight was mainly due to the high reliability of the engine.

The RD is an all-metal monoplane with a large wingspan, powered by one AM-34 engine designed by Mikulin. There were attempts to use this aircraft

as a long-range bomber, but this was not successful because of the plane's low speed at approximately 200 kph.

Between 1930 and 1938 Tupolev supervised the design and construction of prototypes of all-metal multiengined aircraft, the ANT-14, ANT-16, ANT-20. An extreme example of this trend in Soviet aircraft construction was the eight-engined gigantic ANT-20, called the Maxim Gorki, which made its first test flight in June 1934, piloted by M. M. Gromov. The load capacity of the Maxim Gorki was eighty passengers, maximum speed 280 kph, range 2000 km.

During the thirties Soviet aviation and its people, designers and especially pilots, gained much fame, having provided outstanding examples of courage and heroism.

In 1934 the disaster with the icebreaker Chelyuskin occurred. The ship was lost in the Arctic ice, and more than one hundred persons spent the winter in the icy "Shmidt camp." The polar explorers were in deadly danger. The whole country, the whole world watched the rescue operation. After the inhabitants of the ice floes had been flown to the Continent, the Soviet government for the first time bestowed the highest award, the title Hero of the Soviet Union, on seven aviators who had distinguished themselves in the rescue of the Chelyuskin expedition: Lyapidevskii, Levanevskii, Molotov, Kamanin, Slepnev, Vodop'yanov, and Doronin.

This was an era of aviation triumphs. At no time before had aviation ever occupied such a place in the life of the Soviet Union. Soviet pilots entered the world arena of aerial competition. The successes of Soviet aviation were founded on the creative endeavors of designers and on the rapidly growing aircraft industry.

On 21 May 1937 Vodop'yanov landed for the first time in history in the vicinity of the North Pole. The popular Soviet pilot Vladimir Kokkinaki established several height records in Ilyushin's planes. Three women, pilots Grizodubova and Osipenko and navigator Raskova, established the women's world record of long-distance nonstop flights. As happens sometimes in such cases, the enormous achievements in aviation caused not only a natural feeling of pride but also gave rise to smugness. It was widely believed that both sports aviation and combat aviation were firmly entrenched as the world's best.

This mood found its expression in the speech by the People's Commissar of Defense at the 18th Party Congress in March 1939.

"Air Force personnel," said the People's Commissar of Defense K. E. Voroshilov, "increased since 1934 by 138 percent, i.e., almost two- and-a-half times. The number of aircraft increased by 130 percent, i.e., it more than doubled.

"If we express the growing might of the air fleet in horse powers of aircraft engines in comparison with 1934, we obtain an increase by 7,900,000 hp, i.e., an increase of 213 percent over that of five years ago.

"With the quantitative growth of the air fleet its qualitative aspect also changed.

"Here are some data to support this (see table next page).

"What is very important, during that time the proportions of the different types of aircraft within the air force also changed. Heavy bombers increased from 10.6 percent to 20.6 percent, an increase of twice the former share.

Light bombers and attack and reconnaissance planes dropped from 50.2 percent to 26 percent, a reduction of one-half. Fighters increased from 12.3 percent to 30 percent, a two-and-a-half-fold increase. Thus the proportion of types of aircraft doubled in favor of bombers and fighters.

	Increase		
	in speed	of ceiling	of range
Fighters	by 56.5%	21.5%	—
Bombers (short-range)	by 88%	83%	50%
Bombers (long-range)	by 70%	77%	61%
Reconnaissance and attak planes	by 67%	23%	45%

"That means that Soviet aviation has become more powerful and its striking power has increased correspondingly...

"... I may announce that frequently now one finds on our military airfields not only fighters but also bombers with speeds far exceeding 500 kph and a ceiling of 14—15 thousand meters..."*

These data, however, did not reflect accurately the state of the Soviet military aviation. That the proportion of light bombers and attack and reconnaissance planes had been cut to one-half was represented as an achievement demonstrates this inaccuracy. A heavy price had to be paid during the war for having underrated this kind of aircraft.

During the Spanish civil war the first serious signals indicating the danger of boastfulness and smugness were received, warning the workers in the aircraft industry.

When General Franco, supported by interventionist army units and arms of Hitler and Mussolini, unleashed the civil war, the Soviet people, together with progressive people from many countries, came to the aid of Republican Spain. Soviet volunteers with their armament, including aviation, left for Spain in fall 1936 in order to fight in the ranks of the International Antifascist Brigade.

In their book "986 Fighting Days" the Spanish authors M. Ascarate and H. Sandoval wrote about this period:

"In the days of the most terrible danger Madrid received unexpected help."

"For the first time planes appeared in its sky which did not spread death; they brought salvation for the children and women of Madrid; they were chattos (snubnoses) and moscas (midges).

"Ascending to the roofs of their houses, standing on balconies and leaning out of windows, Madrid's inhabitants waved with shawls to welcome the friendly pilots, and they cried—this time for joy!

"At the end of October the first planes arrived in Spain, and a few days later they already flew over Madrid; thanks to them the Spanish and Soviet airmen of the 'Celebrated' squadron were able to repulse the criminal raids of the Italian and German air forces.

"That same month the first fifty tanks arrived; now the Republican infantry had armor, enabling attack on the enemy.

* *XVIII s"ezd Vsesoyuznoi Kommunisticheskoi Partii (b), Stenograficheskii otchet* (The 18th Congress of the All-Union Communist Party (b), Shorthand Protocol).—Politizdat, p. 194—195. 1939.

"The Soviet volunteers who came to Spain rendered the people's army invaluable help because of their experience, with their advice and their great heroism. Among a host of heroes the following were particularly outstanding: Voronov, Batov, Malinovskii, Pavlov, Kuznetsov, Meretskov, Rodimtsev, Serov, Smushkevich, Khol'zunov, Minaev who fell in the defense of Madrid, Gorev, Ptukhin, Krivoshein, Smirnov, Nesterenko and many others."*

At first the Republican airmen fought successfully in I-15 and I-16 fighters, called "snubnoses" by the Spaniards, and SB bombers which received the name "Katyusha." The German and Italian air forces, represented during the first stage of the war by obsolete Fiat and Heinkel fighters and Ju-86 bombers, suffered much damage.

In 1936 the I-15s and I-16s encountered Messerschmitts for the first time. These were the first Me-109B fighters powered by 610 hp Junkers Jumo-210 engines. Their speed did not exceed 470 kph.

The Soviet fighters were as fast as the Messerschmitts and their armament was about equal, 7.62 mm machine guns. The Soviet planes were more maneuverable, and the Messerschmitts suffered serious losses.

This situation strengthened the feeling of satisfaction, and the modernization of the Soviet fighter force was not considered urgent. The Hitlerites, on the other hand, based on the first aerial battles in Spain, began improving their aviation with feverish haste. They radically improved their Me-109, powering it with a Daimler-Benz-601 engine of 1100 hp, which increased the speed of the plane to 570 kph, and arming it with a 20 mm cannon, increasing the firing power of the fighter. This version of the Messerschmidt, the Me-109E, went into serial production.

Some of the first Me-109Es were sent in August 1938 to Spain, where they took part in aerial fights of the final phase of the Spanish tragedy under the command of the best German fighter pilot Melders. The Me-109E had a decided advantage over the I-16, both in speed (100 kph faster) and caliber and range of its firearms.

The Germans made better use of the experience gained in the Spanish war than the Soviet Union. New fighters, Yaks, MiGs, LaGGs, able to hold their own against the Messerschmidts, appeared as late as 1940 as prototypes.

A comparison of the SB bomber in speed and bomb load with the Ju-88 was also unfavorable to the USSR. The Hitlerites had superior bombers. The Soviet dive-bomber Pe-2, like the new fighters, had only its prototype ready in 1940. A plane cooperating with ground forces, similar to the German Ju-87 dive-bomber, practically did not exist in the Soviet air fleet.

At that time A. B. Yumashev and other pilots broke several world records for loads, flying Soviet-made heavy bombers. These records of having the largest load capacity were characteristic for the heavy Soviet aircraft and were creating a great sensation. The task of the bomber is not only to lift the bombs but also to deliver them quickly to the target; yet the heavy Soviet bombers were very slow and their range was also insufficient.

Further, everybody at that time was overwhelmed by the maneuverability of the fighters, believing that this was the decisive quality. Yet it was not taken into account that a fighter plane must first overtake the adversary and then destroy him. What is required is not so much maneuverability as

* Ascarate, M. and Kh. Sandoval. 986 dnei bor'by (986 Fighting Days), pp. 76, 77–79. —Moskva. Izdatel'stvo Progress. 1964. [Russian translation.]

speed and firing power, but the Soviet planes in serial production from 1937-38 had neither.

At the beginning of 1939 anxiety arose in the Soviet Union because of the backwardness of the air force.

The capacity of the aircraft plants, built in the two first five-year plans, was sufficient for the mass production of planes, engines and instruments. The potential of the Soviet aircraft industry was sufficient regarding the number of combat aircraft produced. The problem was that these aircraft were obsolete and were inferior to the standards required by modern warfare.

When we compare the main types of Soviet planes in serial production at the beginning of World War II, i.e., in 1939, with the corresponding German types, the Soviet Union appears to be the worst. "The combat and tactical qualities of the German planes were much better than of the Soviet planes which had been produced during the Second Five-Year Plan ... Our I-16 fighter had a maximum speed of 462 kph, and thus it was no match for the German bombers ..."*

The lessons of Spain caused the government great anxiety. Only extraordinary measures could save the situation.

At the beginning of 1939 the Central Committee of the Party and the government called a broadly attended conference of leading personalities connected with aviation: designers, inventors, managers, scientists, engineers and air force pilots. The conference was attended by designers V. Ya. Klimov, A. A. Mikulin, A. D. Shvetsov, S. V. Ilyushin, N. N. Polikarpov, A. A. Arkhangel'skii, the commander of TsAGI M. N. Shul'zhenko, the author of the present book, and many others. Those present were faced with the problem of how to overcome quickly the backwardness in aviation.

As a result of the conference all those present were enjoined to consider the situation and to make concrete recommendations concerning the problems discussed.

In spring of that same year, 1939, the second conference of aircraft designers took place in the Kremlin. The exact work of each design office was discussed and corresponding decisions were adopted. Conditions for the rapid designing and construction of various types of aircraft were ensured for the designers.

The following took part in designing fighters: Mikoyan, Gurevich, Lavochkin, Sukhoi, Pashinin, Florov, Borovkov, Shevchenko, Kozlov, Polikarpov, Grushin, Yakovlev and Yatsenko.

In 1939 the Defense Committee of the Council of People's Commissars of the USSR adopted two extremely important resolutions. One concerned the building and reconstruction in 1939-41 of enterprises producing aircraft power plants and propellers. The second resolution dealt with the development of aircraft engine plants. Plans were made for building new plants and for the reconstruction of existing plants which should produce engines for combat aircraft. It was necessary at the beginning of 1941 to double the number of aircraft engine plants over that of 1939. To help engine construction, some enterprises were transferred from other branches to the aircraft industry, and production of aircraft engines was organized in some automobile plants. **

* Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza 1941—45 (History of the Great Patriotic War of the Soviet Union 1941—1945), Vol. 1, p. 453.—Moskva, Voenizdat. 1960.

** Ibid, pp. 412—414.

Prewar combat aircraft

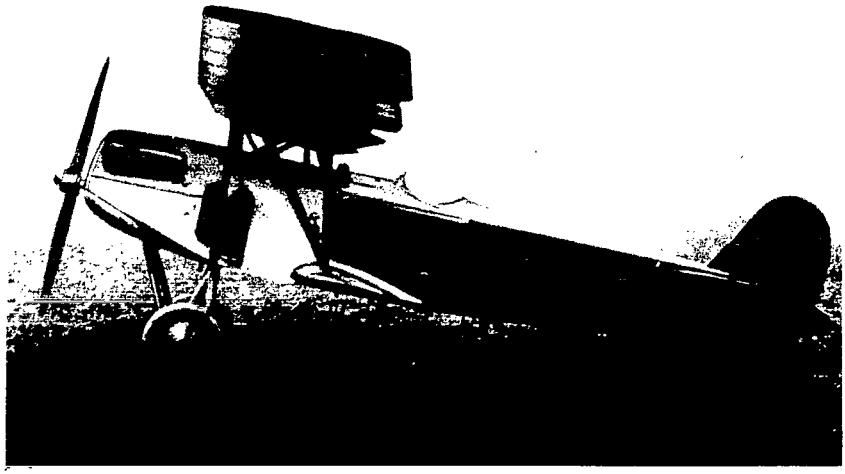
Type of aircraft	Year of production	Engines (type, number, take-off power)	Take-off weight, kg	Armament and bomb load	Crew	Maximum speed, kph	Range, km	Altogether produced
"Fokker D-11"	1922	M-6, 300 hp	1250	2 machine guns 7.62 mm	1	225	575	300
R-1 (DN-9A)	1923	M-5, 400 hp	2217	3 machine guns 7.62 mm; 200 kg bombs	2	200	750	2800
R-3	1925	M-5, 400 hp	2085	3 machine guns 7.62 mm; 200 kg bombs	2	207	750	100
TB-1	1925	M-17, 2 x 500 hp	7775	4 machine guns 7.62 mm; 1000 kg bombs	4	198	1350	216
I-3	1927	M-17, 500 hp	1863	2 machine guns 7.62 mm	1	280	585	399
R-5	1928	M-17, 500 hp	2955	3 machine guns 7.62 mm; 250 kg bombs	2	230	600	7000
TB-3	1930	M-34RN, 4 x 970 hp	21000	8 machine guns 7.62 mm; 2000 kg bombs	8	288	2470	818
I-5	1930	M-22, 480 hp	1355	2 machine guns 7.62 mm	1	286	530	803
I-15	1933	M-25, 715 hp	1373	2 machine guns 7.62 mm	1	362	500	674
I-16	1933	M-25, 715 hp	1422	2 machine guns 7.62 mm		454	820	
		M-62, 1000 hp	1912	2 machine guns 20 mm	1	525	690	6555
				2 machine guns 7.62 mm				
RD	1933	M-34, 860 hp	11500	—	3	246	12411	2
SB	1934	M-100A, 2 x 860 hp	5732	4 machine guns 7.62 mm; 500 kg bombs	3	424	980	6656
I-15 bis	1936	M-25V, 775 hp	1650	2 machine guns 7.62 mm	1	370	770	2408
I-15 Z "Chaika"	1938	M-62, 1000 hp	1859	4 machine guns 7.62 mm	1	443	695	3437

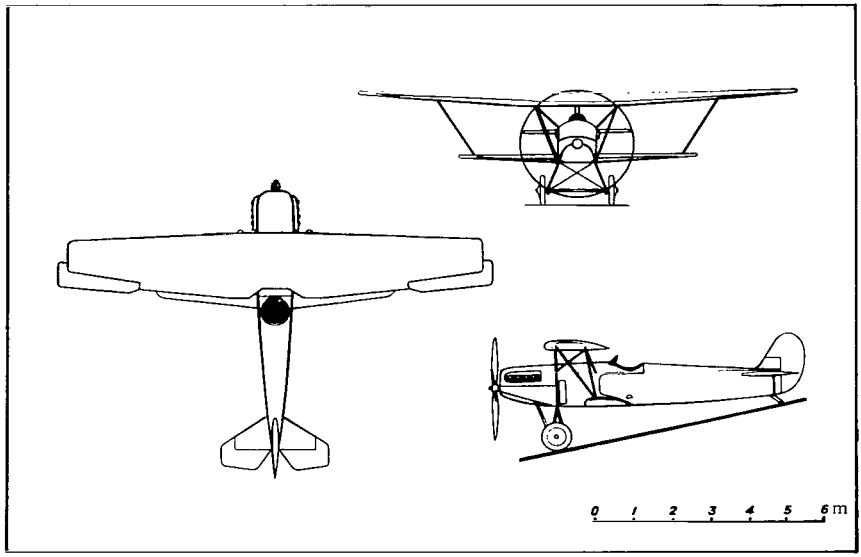
Thanks to the urgent measures taken by the Central Committee and the government, the production base of the aircraft industry was considerably strengthened and the number of design offices and institutions increased greatly. New people joined the teams of designers, working to create new, modern combat aircraft, mainly fighters. A fundamental turning point was reached in aircraft engineering.

Consequently, within a short time, in one-and-a-half to two years, completely new and modern prototypes of fighters, bombers, and attack planes were produced and tested. The ground was prepared for their mass production.

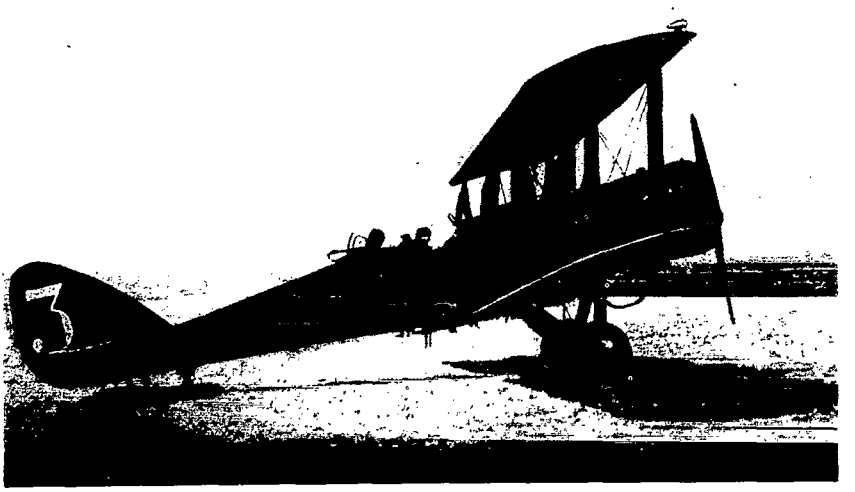
From among all the fighters ordered by the government work progressed best on the LaGG, MiG, and Yak types. These aircraft were tested almost simultaneously at intervals of two or three months. In May and June 1940, without waiting for the end of the tests and on the basis of preliminary results, all these types of aircraft were put into serial production. Equally extensive was the work to put Il-2 attack planes, Il-4 bombers and Pe-2 dive-bombers into serial production.

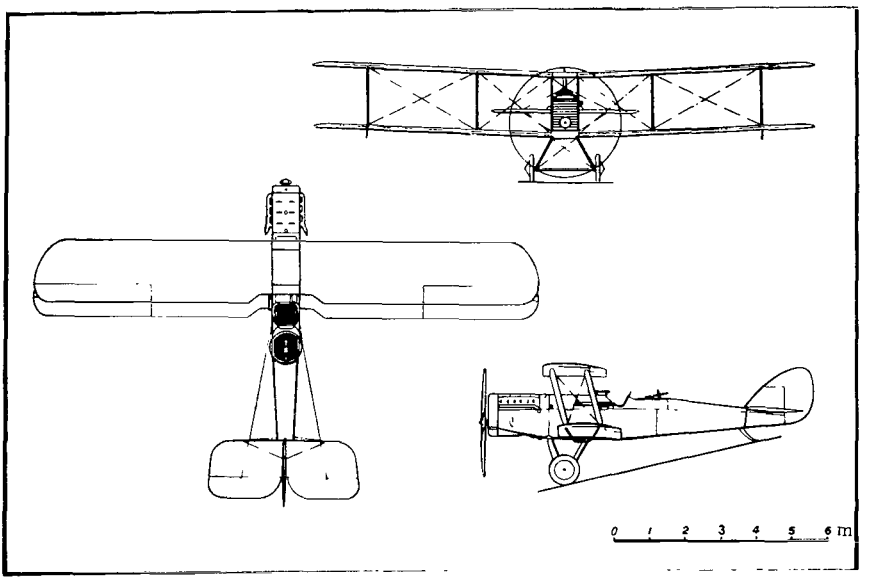
The appearance of aircraft types Il, Pe, MiG, LaGG and Yak did not only mark a fundamental rejuvenation of Soviet combat aviation by supplying it with modern fighters, bombers and attack planes, but it was also extremely important to the government that young and creative designers emerged.



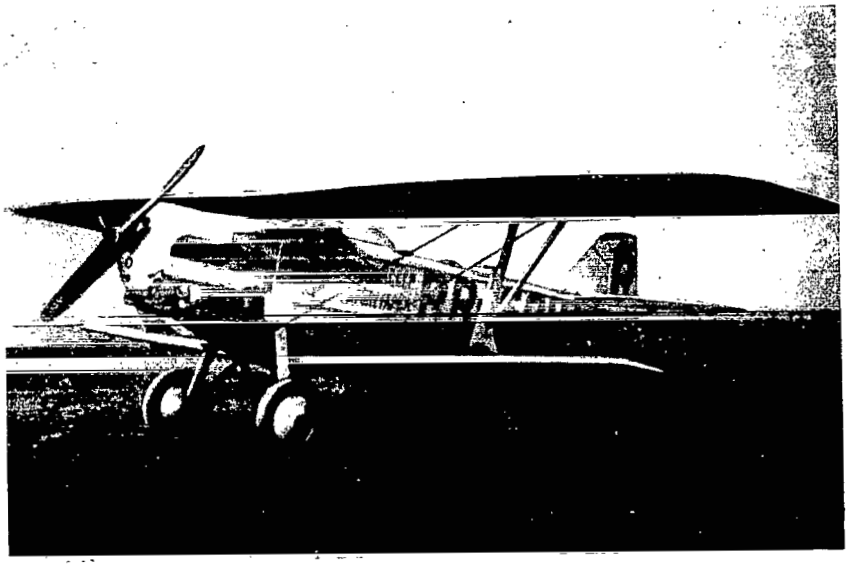


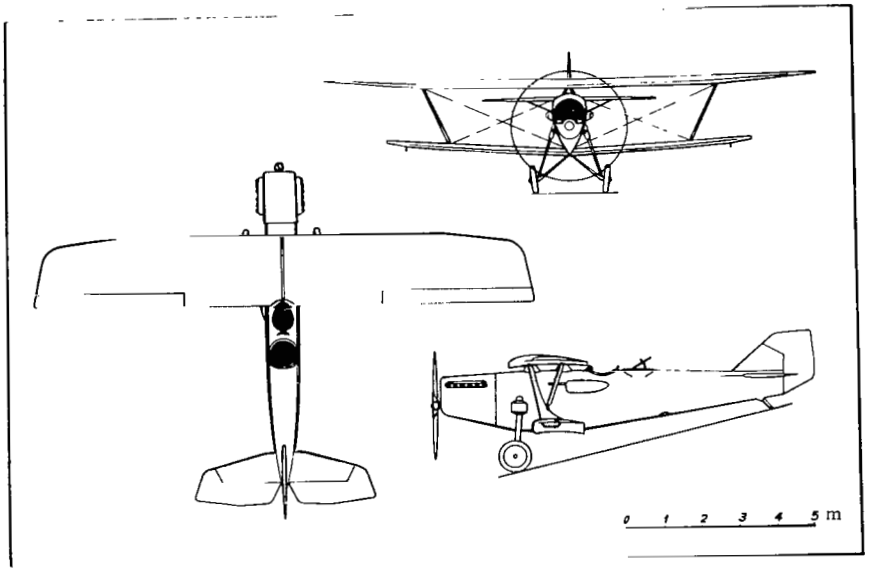
Fighter Fokker D-11, 1922.



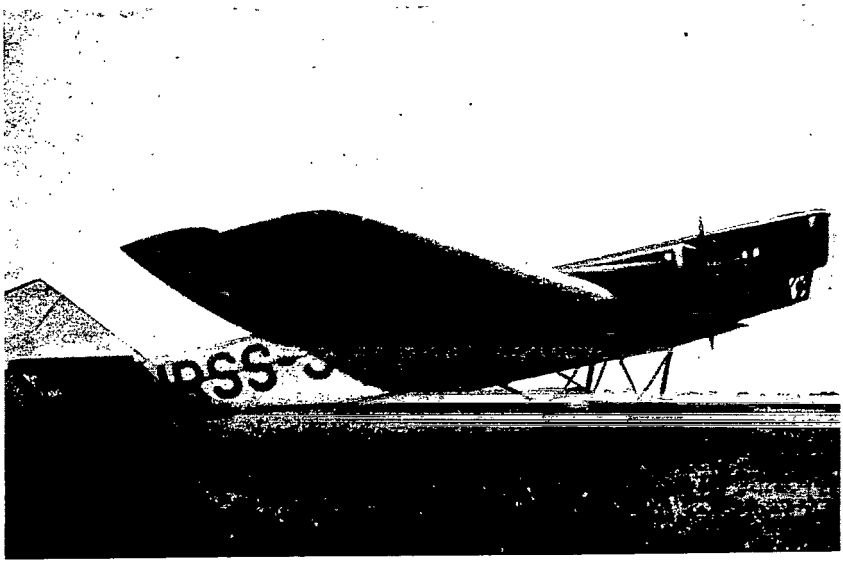


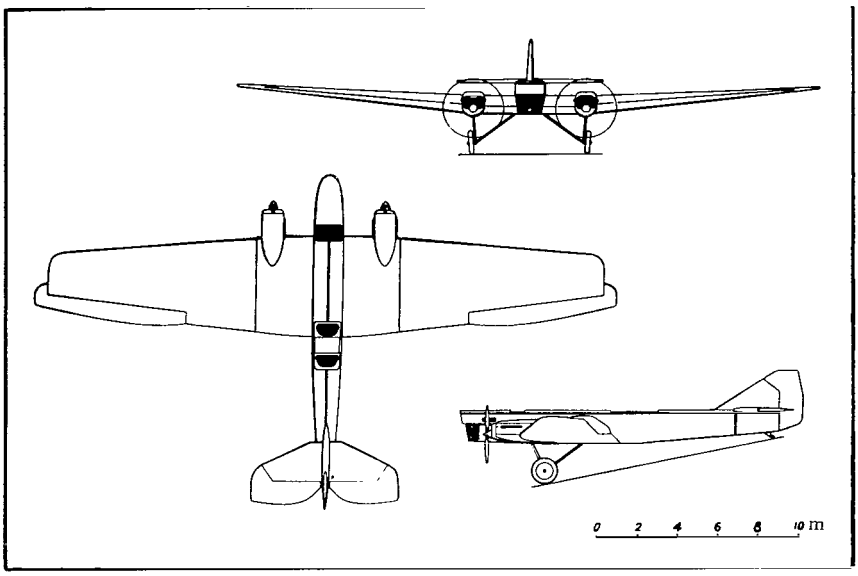
Reconnaissance plane R-1 (DN-9A), 1923.



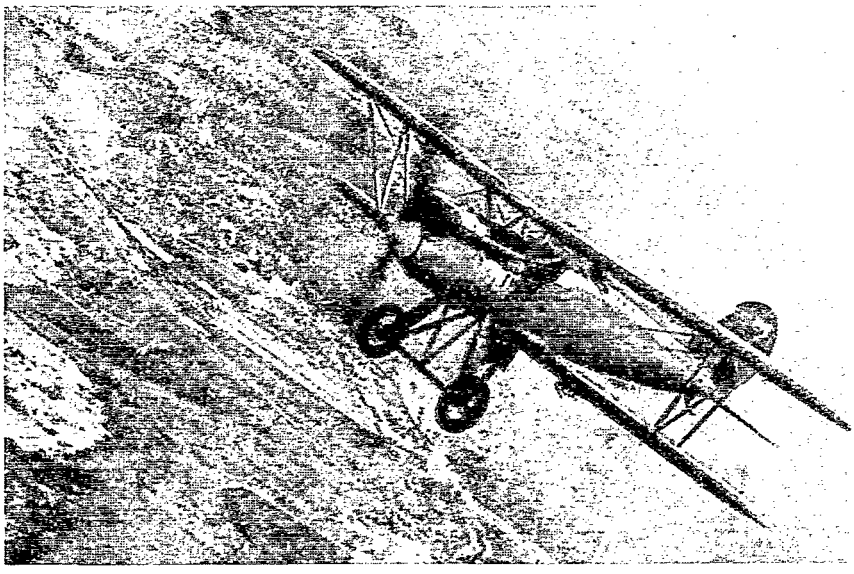


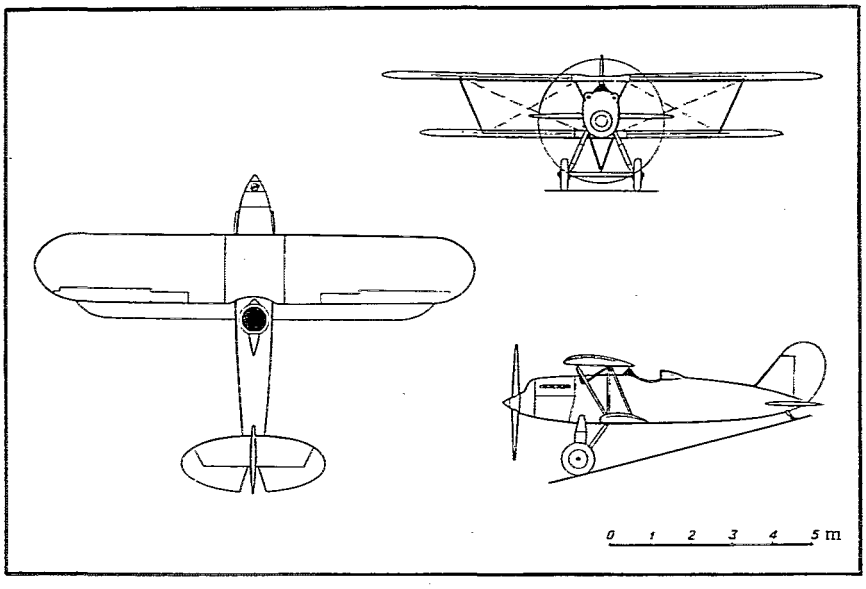
Reconnaissance plane R-3, 1925.



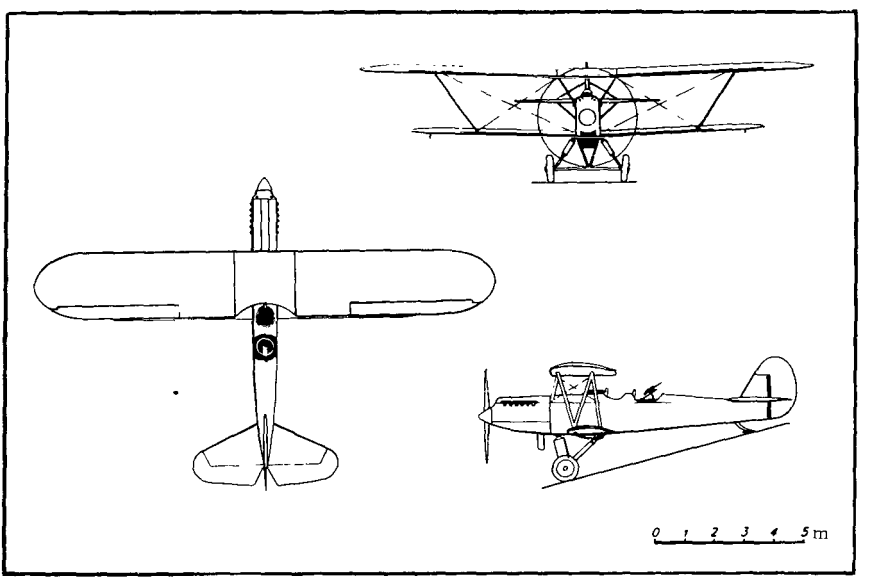


Bomber TB-1, 1925.

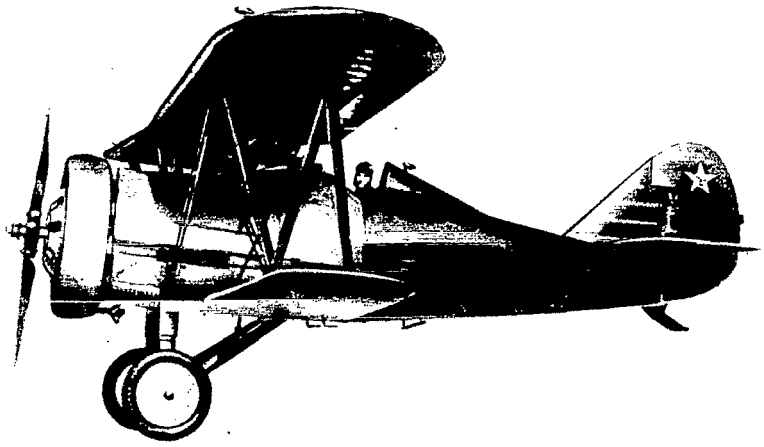


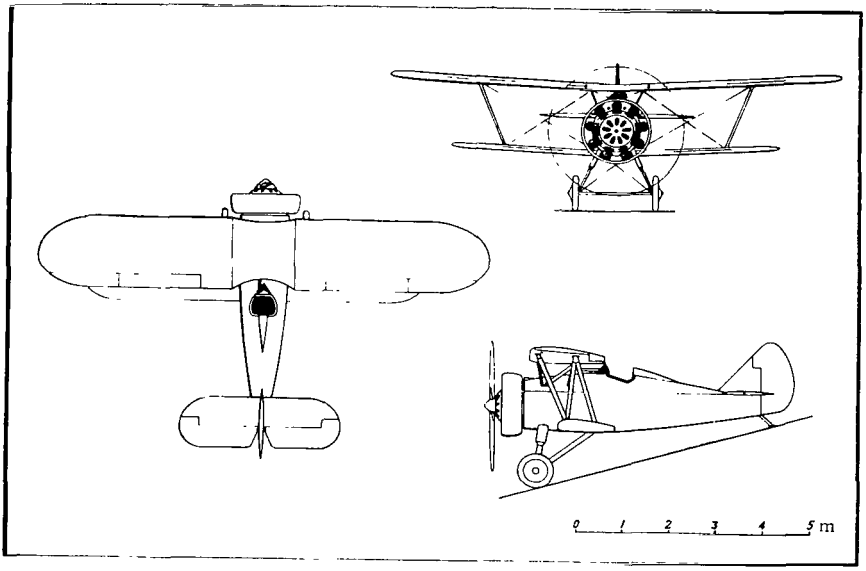


Fighter I-3, 1927.

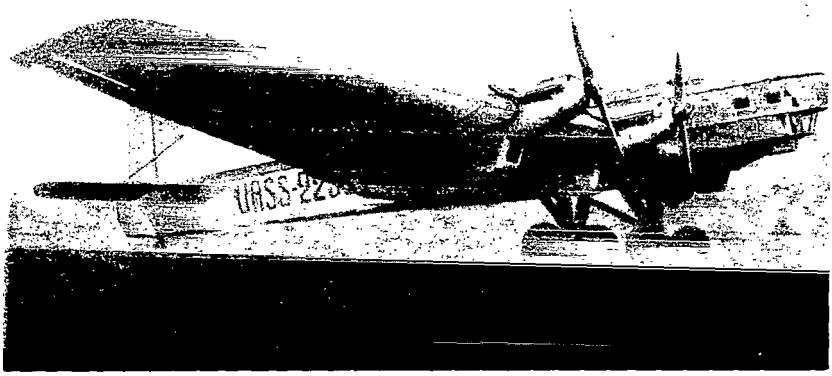


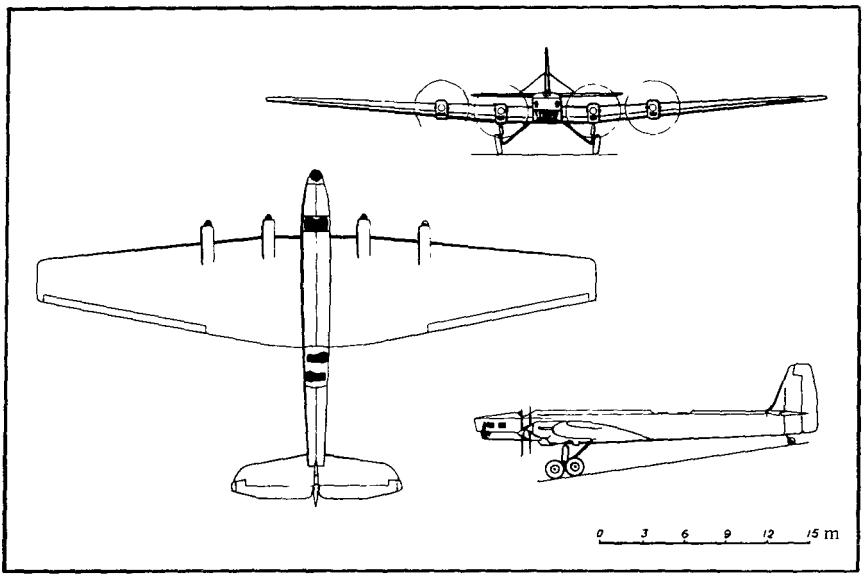
Reconnaissance plane R-5, 1928.



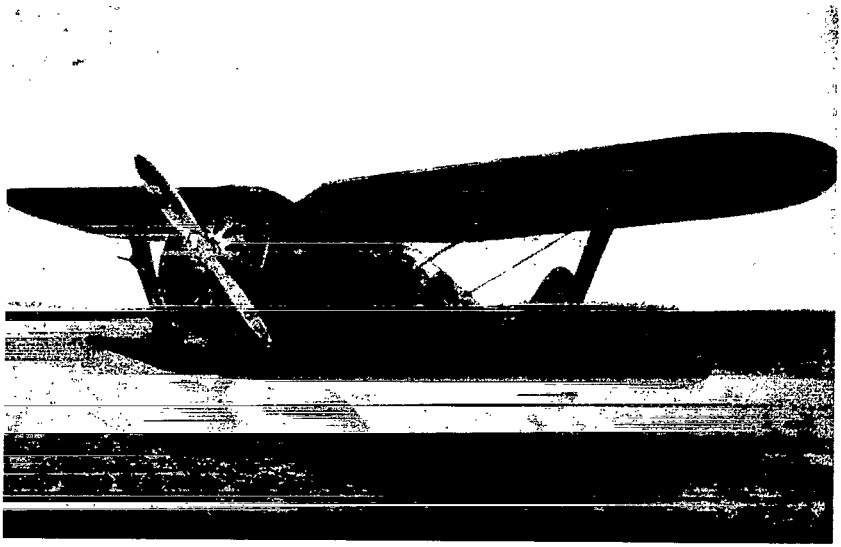


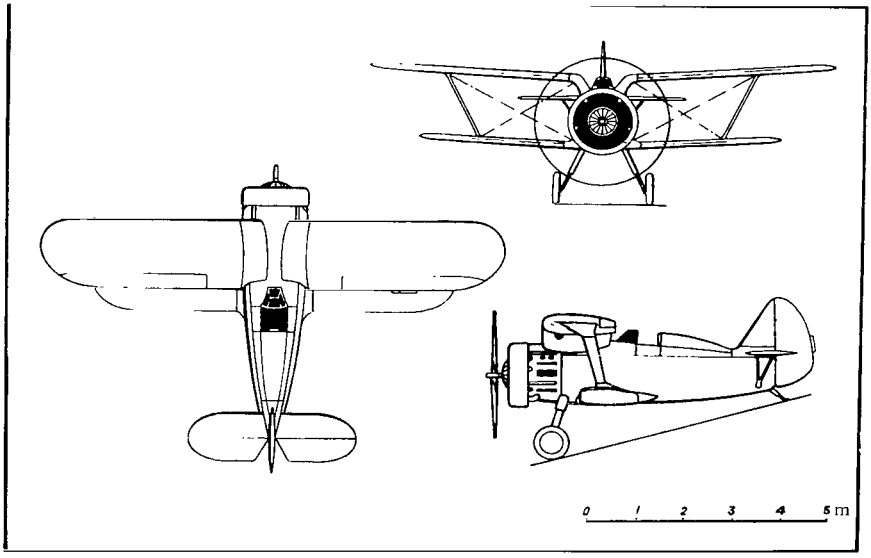
Fighter I-5, 1930.



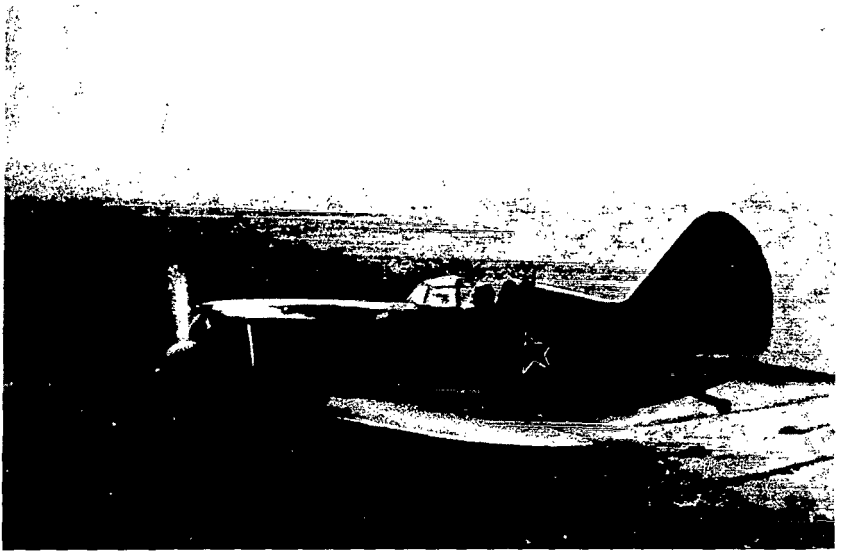


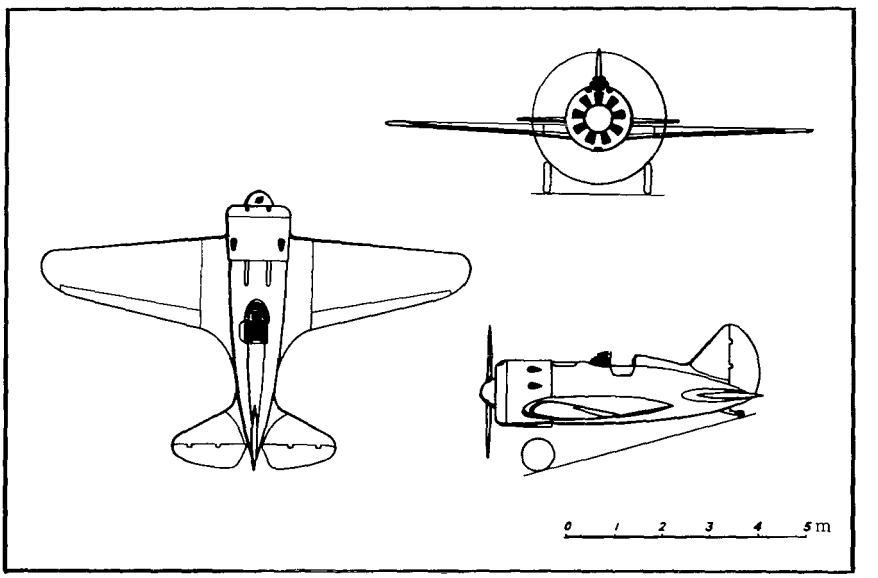
Heavy bomber TB-3, 1930.



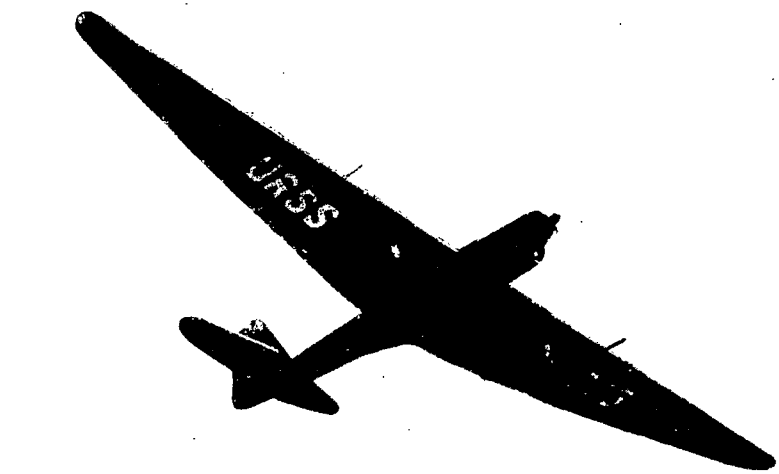


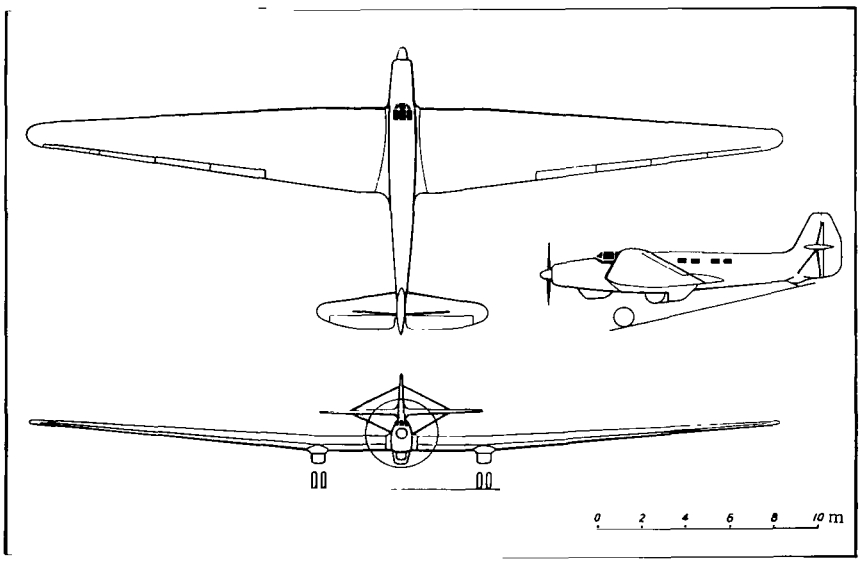
Fighter I-15, 1933.



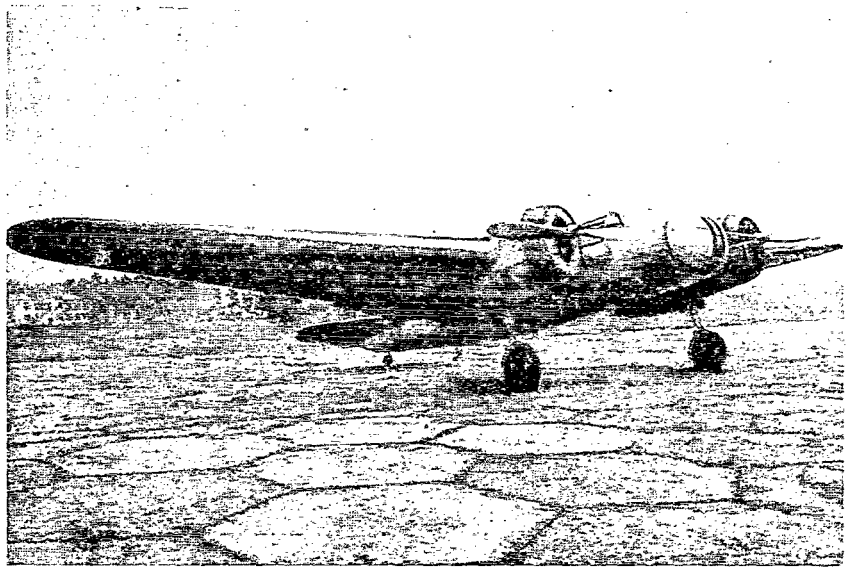


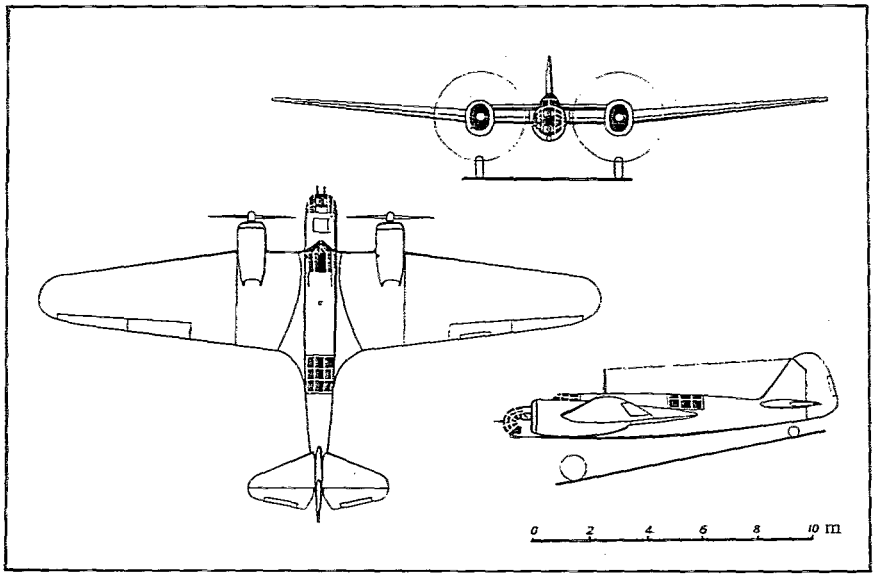
Fighter I-16, 1933.



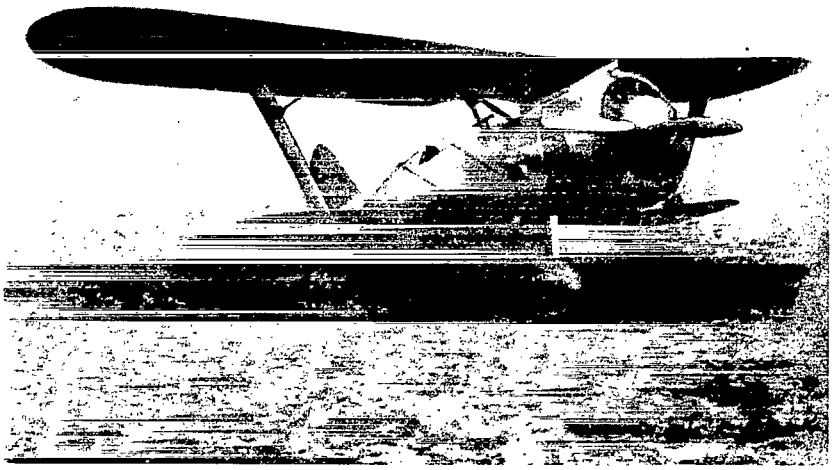


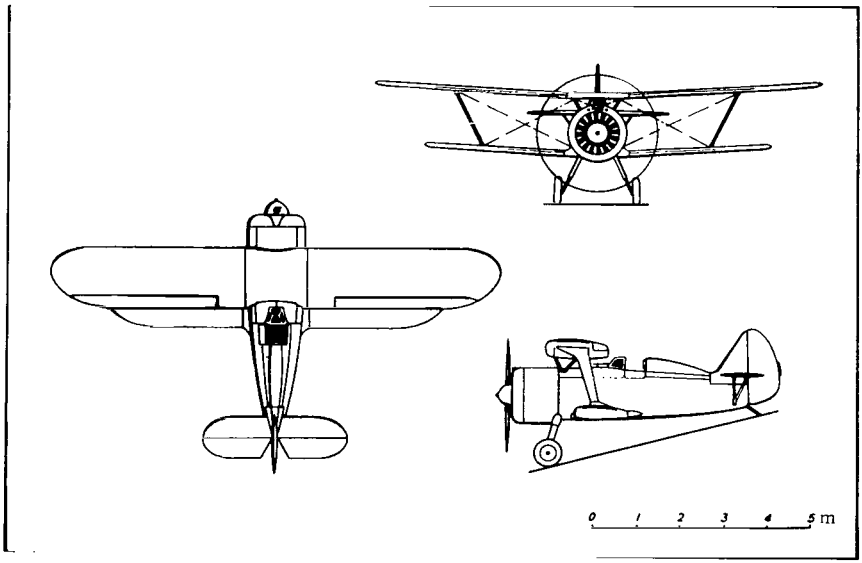
Record-breaking aircraft RD, 1933.



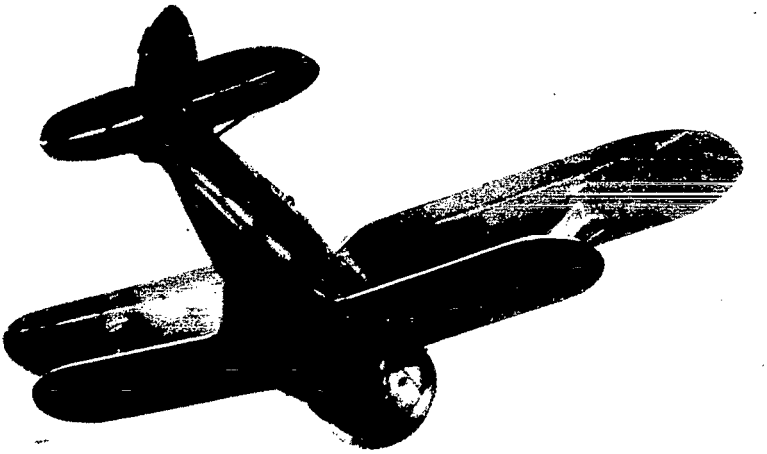


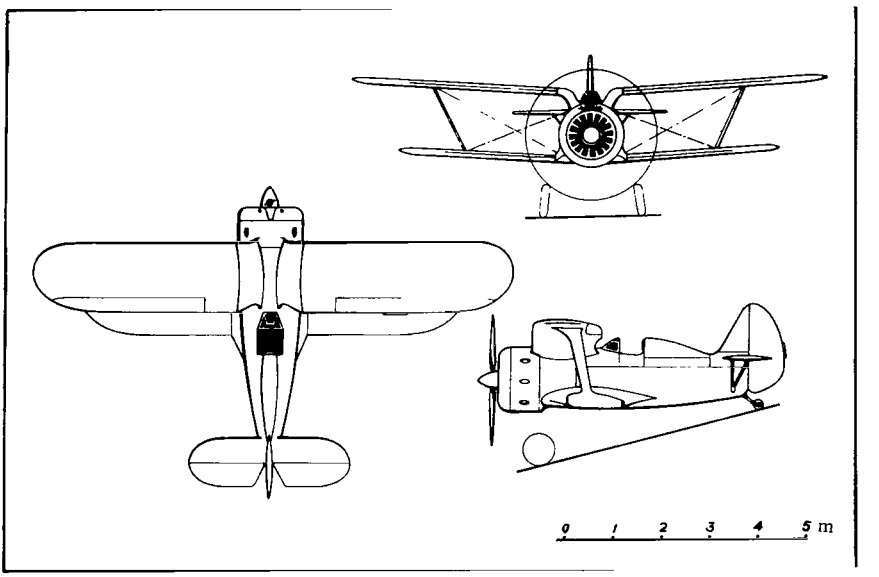
Front-line bomber SB, 1934.





Fighter I-15 bis, 1936.





Fighter I-15 Z, 1938.

3. THE SCIENTIFIC BASIS OF AIRCRAFT CONSTRUCTION

In its development Soviet aircraft construction based itself on the outstanding successes of Soviet science and technology. Problems of speed, range and ceiling were successfully overcome. Soviet aircraft was provided with first-class equipment, instruments and armament. Organization and planning of experimental and design work, including research in aviation, were improved. The ties between science and production became stronger; creative search became embodied in new models of combat aircraft.

The high quality of Soviet aviation science and technology enabled Russian pilots to establish several outstanding world records.

Before the war, when Soviet aviation was about to be reequipped, important organizational measures were implemented, for developing aviation science and rearranging the work of the design offices. In the 48
People's Commissariat of the Aircraft Industry the main administrations of experimental aircraft construction, of engine and instrument production, received additional specialists, principally from among the most prominent air force engineers. The management of TsAGI was also reinforced.

In the thirties the Soviet scientists solved a number of important and fundamental problems of modern aviation to ensure rapid qualitative improvement of Soviet aircraft construction. Among the most important questions were undoubtedly the problems of spin and flutter.

Spin confronted aviation at an early stage of its development. The unexpectedness of spin and the difficulty of pulling the aircraft out of it were for a long time a grave danger. As early as 1916 K. Artseulov, a pilot, deliberately made his aircraft go into a spin, laying the foundation of its practical study. In the twenties the problem of spin became most topical when crashes and disasters were found to have been caused by it. The scientists were required to solve quickly the question of how to design aircraft which would be safe from spin. The point was that as aviation developed, wing loading and flight altitudes increased, and thus spontaneous spin was observed with increasing frequency, which had troublesome consequences. For instance the first series-produced Soviet fighter, the I-1, made in 1923, under certain flight conditions had a tendency to pitch suddenly sideways and go into a protracted spin.

A number of leading Soviet scientists investigated theoretically the question of spin, making it possible to analyze in detail the forces and moments acting on the aircraft under certain flight conditions and to work out the best ways of handling the aircraft to pull it out of the spin. The solution of the problem of spin is credited to two Soviet scientists who specialized in aerodynamics, V. S. Pyshnov and A. N. Zhuravchenko.

V. S. Pyshnov, then assistant at the Air Force Academy, in August 1927 published in the journal "Tekhnika vozdushnogo flota" an article titled "Samovrashchenie i shtopor samoletov" (Autorotation and Spin of Aircraft).

In the history of aviation this was the first scientific theory of spin. In 1929 Pyshnov published this paper "Shtopor samoleta" (Aircraft Spin) which in detail explained the theory of spin and suggested a design of aircraft which would be easy to pull out of spin. He examined many problems of flight dynamics which would facilitate practical application. Various recommendations concerning the loading of aircraft, ensuring correct trimming, pulling out of and going into spin, reducing the tendency to spin, cured aviation of this ill.

Pyshnov's work was presented by the scientific and technical commission of the air force at the World Congress of Scientists in Tokyo in November 1929, and it was officially cited as the first fundamental treatment of the theory of spin, solving most of its mysteries.

In 1934 and 1935 Zhuravchenko published two papers, "Metody resheniya zadach shtopora i ustoichivosti, upravlyaemosti pri potere skorosti" (Methods of Solving Problems of Spin and Stability, Controllability upon Loss of Speed) and "Prognoz shtopora a deistvitel'nyi polet" (Prediction of Spin and Efficient Flight).

On the basis of this fundamental research by Soviet scientists changes in design were proposed and initiated. One of them was a change in the disposition and increase in surface of the horizontal and vertical tail surfaces. Designers began investigating flow about the wing and tail unit at large angles of attack. Before planes were put into serial production, they all underwent investigation of spin, and detailed instructions were worked out on how to handle them in spin. To study conditions of autorotation, TsAGI built a special wind tunnel with a vertical channel. The investigation of spin served as a basis for the study of any spatially unsteady motion of aircraft.

During the early thirties, when flying speed began to exceed 350 kph, Soviet aviation was confronted with another previously unknown phenomenon, flutter. This was the name given to self-excited vibrations of wings and tail units with fast, spontaneously increasing amplitude. The aircraft often vibrated so violently that their structure suffered. The scientists were faced with the task of solving within a short time engineering methods of calculating the speed at which these vibrations may occur (critical speed), and to make practical recommendations for raising it.

The founder of the theory of flutter and of the entire school studying this problem was the distinguished scientist M. V. Keldysh.

As early as in the twenties V. P. Vetchinkin and S. A. Chaplygin studied the vibrations of wings in an air stream, and in 1931 a special group was set up in TsAGI to study vibrations of aircraft in flight, including self-excited vibrations. The investigations carried out in TsAGI by M. V. Keldysh, E. P. Grossman, A. I. Makarevskii and other prominent scientists showed that one of the causes of the natural vibrations is the insufficient rigidity of wings, tail units and fuselage. It was possible to shift the instant at which flutter occurred beyond maximum flying speed by increasing the rigidity of the structure and by adopting various design measures which were also recommended to designers.

Subsequently these recommendations were consistently put into practice. There were recommendations for measures designed to raise the critical speed of flutter. Among them were: to increase the torsional rigidity of the wing and to increase the ratio of the frequency of torsional vibrations

to the frequency of flexural vibrations; to reduce the linear moment of mass inertia of the wing; to have the centers of gravity of the wing sections as far to the front as possible, e.g., by placing the loads in the wing-leading edge, and to move the centers of gravity of the ailerons to the front; to make the wings narrower; to increase the torsional rigidity of the ailerons and the parts of the tail unit; to increase the frequency of antisymmetric vibrations of the tail surface; to lighten the tail surfaces and move their centers of gravity forward.

Scientists also developed methods of computing the critical speeds of torsional and aileron flutter of the wing and torsional and flexural empennage flutter in aircraft of different configurations. The accuracy of the methods was checked on models in wind tunnels and in flight. S. N. Anokhin, a test pilot, in 1934-35 checked the accuracy of the theoretical computations on a glider, and several other pilots did the same on high-speed aircraft. The glider or aircraft gained by dividing the speed at which, according to the computations, self-sustained vibrations should begin. Flight experiments confirmed that the theoretical assumptions were correct.

On the basis of flight experiments and theoretical investigations temporary standards of the strength of aircraft were also worked out. Later on they were constantly revised on the basis of work carried out by V. P. Vetchinkin, A. M. Cheremukhin, A. A. Goryainov, S. N. Shishkin, V. N. Belyaev, A. I. Makarevskii, M. V. Keldysh, and many other scientists. The standards also reflected phenomena that had just been investigated: flight in a turbulent atmosphere, flutter, compressibility, heating. New design features were also considered: stressed skin, swept wings, and so forth.

Material-strength engineering developed as streamlined shapes and designs of aircraft changed by increasing speed, ceiling and unit load. The first series-produced Soviet biplane fighter, the I-2, had in 1925 a speed of barely 230 kph and wing loading was 65 kg/m^2. Less than ten years later the monoplane fighter I-16 had twice that speed, 454 kph, and wing loading of about 100 kg/m^2. Yet another ten years later the Yak-3 fighter attained a speed of 720 kph at about 200 kg/m^2 wing loading. This tendency was maintained, even into the jet era.

Progress in aircraft construction is related to the adoption of new configurations and design features would be unthinkable without the pioneering efforts of material-strength specialists. Whereas in the early stages of development of Soviet aviation calculations and stress analyses were carried out according to primitive standards (from today's point of view) and were checked only by elementary static tests, later investigations of aeroelasticity were added to static stress analysis, with aerothermoelasticity, the theory of thin-walled structures and shells following. Afterward fatigue tests on the ground and flight tests with strain gauges began.

Important for the practical utilization of the scientific investigations and their technical application was the Designers' Handbook (Rukovodstvo dlya konstruktorov (RDK)) which unified methods of design, construction and testing of aircraft.

This handbook was needed because the design offices did not use the same methods. Each office worked according to its own rules, and frankly, not always successfully. The only law obligatory for all covered the strength standards for aircraft. Everybody abided by it. Other methodological problems were not dealt with, and even the testing of aircraft in wind

tunnels was arranged by each designer in his own way. Procedures in designing, constructing and testing aircraft were not subject to any regulations. The work was not infrequently unsystematic, eventually causing great and sometimes unjustified expenditure of material and labor.

As long as there were only two or three design offices in the country and they were as highly skilled as Tupolev's and Polikarpov's, they could somehow manage without regulations, although unified direction was even then advantageous. But when there were many design offices, it was unthinkable that they should work without a unifying methodological "codex." All this was especially well understood when, as a result of the unsystematic and unorganized work in 1940 and 1941, several new aircraft crashed on test flights.

The first edition of the RDK handbook was prepared in 1940 and published in 1941. The second edition, considerably revised and enlarged by more than one hundred fifty printing sheets, was published after the Soviet Union had entered the war. It incorporated the experience in design, construction and combat of the new generation of Soviet aircraft which appeared shortly before and during World War II—the Yak, La, and MiG fighters, the Il-2 attack planes, and the Il-4, Pe-2 and Tu-2 bombers.

The first edition consisted only of five parts and the second edition in three volumes had no less than eleven parts:

1. Aerodynamics
2. Hydromechanics
3. Strength of materials
4. Flight tests of aircraft and equipment
5. Engines
6. Aircraft equipment
7. Aircraft armament
8. Landing gear and mechanisms
9. Standard systems
10. Materials
11. Semiproducts.

The first edition of the RDK handbook was prepared with the cooperation of leading scientists, designers and test pilots. The scientific editors of parts and chapters were I. V. Ostoslavskii, aerodynamics; L. I. Sedov, hydromechanics; S. N. Shishkin, strength of materials; A. I. Makarevskii, chapter on strength standards; M. V. Keldysh, chapters on dynamic and vibration investigations, and computation of flutter; A. V. Chesalov, flight tests, landing gear and mechanisms; V. I. Polikovskii, engines; G. V. Akimov and S. T. Kishkin, materials; N. I. Petrov, aircraft equipment; P. Ya. Zalesskii, armament; and A. T. Tumanov, materials. Authors of parts of the RDK handbook were M. A. Taits, N. S. Stroev, V. V. Kostochkin, G. P. Svintsev, A. A. Dorodnitsyn, V. V. Struminskii, and many others.

The RDK handbook contains descriptions of wind tunnels and tests in them; requirements of wind-tunnel models of wings and aircraft and of mock-ups; data on the aerodynamics of wings; detailed recommendations for the selection of unit load, profile, etc., for the design of the tail unit, controls, and ailerons, and for the arrangement of the power plant; basic characteristics and recommendations for the selection of propellers and the computation of their thrust; information on unified propellers; data on the

determination of the stability and controllability of the aircraft from model experiments, on the longitudinal and lateral stability of aircraft, and on the selection of horizontal and vertical tail surfaces.

The chapters of the RDK handbook dealing with hydromechanics were extremely valuable to the designers of seaplanes. Here the experimental basin of TsAGI and experiments in it were described. Also hydrostatic computations were given, including the computation of unsinkability and hydrodynamic analysis of seaplanes.

Especially detailed was the treatment of problems of strength of materials. In addition to the "Strength Standards" in the handbook, there are regulations for the extent and sequence of static and dynamic tests, for the determination of vibration characteristics, and for the computations of flutter. The treatment in the book excels by being detailed and instructive.

An entire part of the RDK handbook deals with flight tests of aircraft and their equipment. Programs and documentation of the aircraft tests are given; tests for stability, controllability, maneuverability and spin; tests of the power plant, of equipment, of firearms and bomber armament, of the mechanisms of the landing gear, controls, and landing systems; and the instruments for flight tests are described.

Several chapters of the RDK handbook deal with the engines and accessories and contain requirements and samples concerning design and methods of testing such systems as gas, oil, liquid cooling, suction, exhaust, radiators and cowlings, and control of the power plant. The most detailed chapter is "Radiators and Cowlings", because the optimum design of these parts is important for reducing the resistance of aircraft.

The part of the handbook entitled "Aircraft Equipment" deals with flight and navigation instruments and electrical, radio, and high-flying equipment. It gives information on the obligatory nomenclature of instruments and equipment depending on the class of the aircraft, its tactical destination, crew, and number of engines. Standard arrangements of instruments in cockpits of fighters and attack planes are recommended.

The subsequent section, "Aircraft Armament", consists of chapters on firearms and bomber, mine, and torpedo armament, rocket missiles, and armoring of aircraft.

Interesting is the chapter dealing with rocket missiles; it is an abridged version of "Kratkoe rukovodstvo po primeneniyu raketnykh snaryadov s samoletov" (Brief Manual on the Use of Rocket Missiles Fired from Aircraft). Soviet aviation was the first in the world to be equipped with rockets and used successfully in the fighting on the Khalkhin-Gol. After that the rockets "came down to earth", becoming the terrifying Guard mortars, the "Katyushas." The chapter also contains general instructions for the armoring of aircraft, information on armor plating and its characteristics. Finally there are technical recommendations for the design of armor parts and armored structures of aircraft. Particularly it is proved that armoring of the main types of combat aircraft-fighters, bombers, attack planes and reconnaissance planes—is obligatory. Those sections most vulnerable for the crew are protected by armor.

The RDK handbook devotes much attention to the treatment of touch-down installations. In particular the problem is analyzed of standardization of control cabins in different types of aircraft and of location of armament in the bombardier's compartment and in the cockpits of fighters and attack planes.

Two sections of the RDK handbook contain descriptions of the physical and mechanical properties of the main aviation materials.

This entire encyclopedia for aircraft designers, rich in content, was compiled within a short time. It played an eminent part in improving the work of the design offices and was a vital link connecting science and practice.

The People's Commissariat of the Aircraft Industry gave high priority to organizing design offices and research institutes. The range of problems of research institutes was relieved of subjects that were not urgent and topical, and the scientists' work was oriented toward the solution of the most important problems, both short-term and long-term ones. Emphasis was placed on the construction of new wind tunnels with high air velocities and of gigantic laboratories for static and dynamic tests where designers could check the strength of aircraft on highly scientific lines. Everything was done to ensure that aircraft designers could utilize the latest scientific investigations.

Design offices, research institutes and industrial plants made a supreme effort to ensure that the new models of aircraft and engines were series-produced as soon as possible. The introduction of new aircraft and techniques demonstrated the necessity to rebuild the radio industry, to create high-quality metallurgy, to reorganize tens or even hundreds of enterprises in various branches of the economy working for the aircraft industry.

The prewar period is characterized by the parallel development of all-metal heavy aircraft with dural skin and light maneuverable aircraft of composite construction. As the raw-material base expanded and the Soviet aluminum industry developed, aluminum alloys were increasingly used. After having been tested on the experimental ANT-2 plane, the TB-1 (ANT-4) bomber was built; here the skin was made of corrugated duralumin-type sheet and was stressed in shear and torsion. After the TB-1 all bombers and their transport versions had metal skins, and beginning with the SB the skin also covered the fuselage and was fully stressed.

Dural parts also found application in some cases in light combat aircraft (fighters and reconnaissance planes). On the whole, however, these aircraft had truss frames made of steel pipes with fabric skin and wings with wooden spars and fabric skin, later replaced by plywood skin. Emphasis was placed on cheap materials in ample supply; this proved to be best under conditions of mass production. Its justification became apparent during the war when the enemy occupied Zaporozhe and Volkhov, where the aluminum plants were located, thus stopping almost completely the production of aluminum for some time. When it was possible, still during the war, to resume production of aluminum in the Urals, duralumin was used more widely, including on fighters, e.g., the wooden spars were replaced by metal ones; this made it possible to reduce the weight of the structure and to increase the space available for fuel. The wing skin at first was made of plywood. Only toward the end of the war was it replaced by metal skin.

In the thirties attempts were made to build passenger planes with frames of stainless steel sections. This trend, however, was discontinued because of the high cost of the material and technological difficulties.

It is no exaggeration that even before the war Soviet aviation science and industry had accumulated vast experience. On the basis of the latest

achievements of science and technology, prototypes of first-class modern combat aircraft were built; however the problem was more complicated than just to build new models of aircraft, engines, various instruments, and to invent new materials. It was necessary to organize mass production of all these aircraft and everything else required, which was now on an incomparably higher level than before.

The rapid mastering of the most advanced aviation techniques largely depended on the courageous and self-sacrificing work of the test pilots who often risked their lives to test the performance of aircraft under the most complicated and dangerous flight conditions. They were the most important and most highly skilled advisers of the designers.

As a result of energetic and tenacious efforts, Soviet aviation was qualitatively renewed within a short time. Thanks to the measures taken, all the required types of combat aircraft were put into serial production. However, at the beginning of the war their output was still small. It was not possible to remedy the situation at the time Hitlerite Germany attacked the Soviet Union.

4. WORLD WAR II

World War II was a stringent test for the entire Soviet people and the Soviet army. The air force was in a particularly difficult position. Production of modern combat aircraft was not able to supply the required numbers at the beginning of the war.

The aircraft industry overcame the difficulties caused by the sudden attack of Nazi Germany, evacuating entire enterprises to eastern districts of the country and raising the daily rate of armament production. In 1943 the Soviet aviation gained the upper hand in the air, having outstripped the enemy both in quantity and quality of aircraft.

Toward the end of the war Soviet control of the air was complete; the remainder of the Luftwaffe turned to to dust.

The spread of Nazi aggression in Europe led inexorably to the unleashing of war by Germany against the Soviet Union. The prewar atmosphere was also clearly felt in the Soviet aviation industry.

At the beginning of 1941 the Central Committee and the government deliberated on how to improve the work of the aviation industry and strengthen the air force. It was necessary to produce in the largest possible numbers new types of aircraft that had been developed by then.

On 25 February 1941 the Central Committee of the Party and the Council of People's Commissars adopted an important resolution, "On the Reorganization of the Red Army Aviation." This resolution confirmed the plan of rearming the air force units, prepared by the People's Commissariat of Defense. The aim was to form new units with half of them to be equipped with modern aircraft, as much as production permitted. The formation of several air force units began. Zones of air defense with fighter aircraft, antiaircraft artillery and observation service were introduced. It was envisaged that most flyers would be taught to handle the new aircraft during 1941.

The Central Committee and the government also dealt with partial and special problems. In winter 1940 the problem of the difficulties in operating the new high-speed fighters and bombers was discussed, because the snow had not been removed on airfields. Take-off on skis, technical difficulties of retracting the landing gear with skis, loss of speed because of the increased air resistance—all this put the Soviet aircraft at a disadvantage against foreign aircraft. Although the air force command protested because it believed it impossible to remove the snow from the many field aerodromes, the Central Committee and the Soviet government proposed that henceforth aerodromes be cleaned and rolled. Since then Soviet combat aircraft have been running on wheels, summer and winter.

In early summer 1941 leading employees of the People's Commissariat of the Aircraft Industry and of the army air force were invited to meet the Central Committee and government to discuss a letter received from an airman who complained of the complete absence of camouflage on aircraft

and aerodromes in the border regions. During the deliberations it was discovered that one of the institutes of the People's Commissariat of Defense had been preparing samples of camouflage for a long time. It had several versions of camouflage paint for aircraft ready but had not suggested a final version. An order was issued to submit a proposal for aircraft camouflage within three days. Within the stipulated time one design office prepared aircraft models of differing types with camouflage. After the problem had been studied by the People's Commissariat of the Aircraft Industry, together with representatives of the army air force, the models were approved, and the army air force was to camouflage all aircraft within the shortest possible time.

These and other facts indicated that the country sensed the advent of war. Nevertheless the attack by the Nazis against the Soviet Union came unexpectedly. It put the Soviet armed forces, including the air force, into a difficult position.

Although the Soviet-designed fighters, LaGG-3, MiG-3 and Yak-1, were faster and more maneuverable than their German counterparts and S. V. Ilyushin's attack plane was unique, their series production was only just being started.

The single-seater, all-wood LaGG-3 fighter had a speed of 570 kph and carried one 20-mm cannon and one 12.7-mm machine gun. It made extensive use of improved wood (delta wood, i.e., wood impregnated with phenolic resin, which is very strong) and was powered by a liquid-cooled 1050 hp engine, type M-105P.

The MiG-1, and then its modification, the MiG-3, were specially designed as high-altitude fighters. The MiG-3 was a monoplane of composite construction with plywood and metal covering, powered by an AM-35A, 1350 hp engine, and its take-off weight was 3350 kg. The armament of the plane consisted of one 12.7-mm machine gun and two 7.62-mm machine guns. Its maximum speed was 640 kph at an altitude of 7800 m.

The Yak-1 fighter was the first in the series of Yak fighters.

All these planes had several features in common: low weight, easy piloting, extremely simple design, made of readily available materials, suitability for mass production. It had all-wood, unslotted wings with two spars, plywood covering, and a truss fuselage of welded steel pipes covered with canvas. The plane weighed 2.9 tons and had a speed of 580 kph. Its armament consisted of one 20-mm cannon and two 7.62-mm machine guns. The M-105P V-type engine was liquid cooled, of 1050 hp, designed by V. Ya. Klimov; the cannon was situated between the banks of the V. The gun barrel was located inside the hollow reducer shaft, permitting firing without a synchronizer and a larger caliber. Although the Yak-7 was available almost at the same time, the Yak-1 was developed independently of it throughout the war. They were produced continually in different versions.

The armored attack plane Il-2, which was destined to become the most widely used aircraft in World War II, was designed in 1938 in Ilyushin's office. At first the Il-2 was received coolly from the military. They thought its speed, range and armor were insufficient. They wanted Ilyushin to change the aircraft from a two-seater, with a machine gun for the defense of the rear half sphere, into a single-seater without defensive armament. During the war, however, the single-seater Il-2s suffered considerable losses and it was necessary to revert to the two-seater version.

The Il-2 was not the first attempt to build an aircraft that would act as a tank destroyer. Yet only Ilyushin succeeded in fully solving this complicated problem by designing an astonishingly lively plane whose favorable features enhanced one another, with powerful armor and armament which was constantly improved. The plane was intended to fight tanks, and it was itself a kind of "flying tank." The designer produced a single, compact, welded armored cell. It encompassed the entire nose and center of the fuselage and provided reliable protection for the crew in both cabins, the engine and radiator, fuel tanks, and other vital parts of the aircraft. With a take-off weight of less than 6 tons, the armor weighed more than 700 kg. The armored shell was also part of the stressed airframe, which was why such a comparatively low weight of the aircraft could be attained. The rear section of the Il-2 was wooden, wings and empennage were of duralumin. At the time of the war the Il-2 was powered by a liquid-cooled AM-38F, 1750 hp engine. The plane had a speed of 420 kph and a range of more than 750 km. Its armament consisted of two 23-mm cannons, type VYa, two wing-mounted machine guns, four rocket missiles of 82- and 132-mm caliber, and 400 kg to 600 kg bombs carried in the bomb bay or under the wings. Defensive armament was a 12.7-mm machine gun in the cabin of the gunner-radio operator.

The Il-2 attack planes were used in combat right from the beginning of the war and immediately acquired an excellent reputation. To the Germans their appearance was a complete surprise.

Series production of the Il-2 increased daily until output reached forty planes a day. At the same time the aircraft was being improved. In the battle of Kursk the Il-2s were equipped with two 37-mm cannons and with special antitank bombs.

The high-speed dive-bomber Pe-2, designed by V. M. Petlyakov, was also put into mass production. It was powered by two 1100 hp, liquid-cooled M-105R engines, with water and oil radiators flush with the wings. The new bomber was of all-metal construction, beautifully streamlined; it excelled by its small dimensions and low resistance. The weight of the Pe-2 did not exceed 8.5 tons. With its speed of 540 kph the aircraft was almost equal to the enemy fighter, the Me-109E, which operated in the first period of the war on the Soviet-German front. Compared with its predecessor, the SB, the Pe-2 was 120 kph faster. With a range of 1200 km it could carry 600 kg of bombs; the overload version carried 1000 kg of bombs. The equipment of the plane ensured accurate dive-bombing. Against enemy fighters the plane was armed with five machine guns operated by the pilot, the navigator and the gunner-radio operator. During the war the Pe-2 was also built in the reconnaissance version with extra camera mountings and fuel tanks. The Pe-2 was the main short-range bombing and reconnaissance plane of the Soviet Union, and it was found to be efficient at the front.

Total aircraft output in 1940 was sixty-four Yak-1 fighters, twenty MiG-3 fighters, two Pe-2 dive-bombers. In the first half of 1941, the following planes were in production: 1946 MiG-3, Yak-1, and LaGG-3 fighters, 458 Pe-2 bombers and 249 Il-2 attack planes; but most of the combat planes of the air force were still outdated models.

On the first day of the war the Soviet air force suffered heavy losses. The German air force attacked sixty-six aerodromes near the Soviet border. By noon of 22 June 1941 the Soviet Union had lost twelve hundred planes:

three hundred were shot down in dogfights and nine hundred were destroyed on the ground.

The Soviet aerodromes in the border districts were not ready when war broke out. According to the existing plans, by 1941 the old aerodromes should have been adapted to the new types of aircraft and new aerodromes built. The intention was to reconstruct the aerodromes successively so that not all of them would be out of action at the same time. The "History of the Great Patriotic War" (Istoriya Velikoi Otechestvennoi voiny) states, however, that "in spring 1941 the People's Commissariat of Internal Affairs, which was charged with the construction work, did not consider the situation and began construction simultaneously on most of the aerodromes in the border districts. The result was that at the outbreak of war an extensive part of these aerodromes was actually unsuitable for operation under combat conditions; all the fighters were concentrated on a few aerodromes, depriving them of the possibility of maneuvering and making camouflage and dispersal difficult. Some aerodromes, e.g., in the Western Special Military District, were too close to the border making them exceedingly vulnerable in case of sudden attack by enemy aircraft. The lack of a network of aerodromes on 22 June 1941, the cramped conditions of air force units on the few peace-time aerodromes, of which many were well known to the enemy, were some of the reasons for the heavy losses that Soviet aviation suffered in the first days of the war. The civil defense warning network in the western border zone was badly organized, and air force units received belated information on the violation of the country's border by German planes.

"At the outbreak of the war the air force in the border districts was engaged in widespread reorganization and retraining of personnel."*

In the fighting that followed, in spite of their heavy losses and flying obsolete planes, the Soviet pilots managed to inflict serious damage on the Germans. For example, in less than a month, between 22 June and 19 July, the German army lost about thirteen hundred planes in aerial combat.

In his postwar memoirs Greffrat, a military historian and member of the German General Staff, wrote: "In the period from 22 June to 5 July 1941 the German Luftwaffe lost 807 planes of all types, and from 6 to 19 July 477 planes. These losses prove that in spite of the surprise achieved by the Germans, the Russians found time and strength for determined counterattack."**

This successful counterattack completely surprised the Germans and robbed them of the chance to send part of their air force against the West, as they had planned, because it forced them to reinforce their aviation on the Soviet front at the expense of their strength in the West.

Regardless of losses, the Germans threw fighters and bombers, that were new in every respect, into the fighting. They concentrated 4840 aircraft on the Soviet-German front, of which 3940 were German, 500 Finnish, and 500 Rumanian, and thus achieved air superiority.

The Soviet industry was unable to replace the losses the Soviet air force had suffered in the first days of the war. In addition, in view of the rapid

* Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza... (History of the Great Patriotic War of the Soviet Union), Vol. 1, pp. 476–477.

** Mirovaya voina 1939–1945 (The World War 1939–1945), p. 472. – Moskva, IL. 1957.

advance of the German army, one aircraft factory after the other in the European part of the USSR, and thus within range of German bombers, stopped work and was dismantled. As early as 5 July 1941 the Council of People's Commissars decided to evacuate part of the equipment of plants producing aircraft instruments from the Central regions of the country to Western Siberia to duplicate their production. Later came the decision to evacuate the entire aircraft industry. The output of new types of combat aircraft dropped sharply, and the old fighters and bombers, such as the I-15, I-16, SB, and TB-3, were no match for the Messerschmitts and Junkers.

It was clear now that the trouble in which Soviet aviation found itself in June 1941 was also because of the errors committed in the thirties. This is how we view them now, many years later.

Some of the Soviet tacticians were influenced by Douhet's doctrine (although it was officially rejected in the USSR) of the omnipotence of a strong bomber force. The effect was that the role of heavy bombers was overrated and the role of attack planes and light bombers was underestimated.

The technical policy in aircraft construction mostly emphasized production of heavy and superheavy planes. Heavy bombers were made in large series. Finally the gigantic planes were impressive at military reviews; they testified to the increased potential of the Soviet aircraft industry and the achievements of Soviet aircraft technology, but experience in the last war demonstrated that they are not a decisive force.

The negative aspect of this gigantomania and even of records achieved at that time was that they induced a feeling of smugness and the illusion that aviation was able to seal off the border.

It was also a mistake that up to the late thirties, the Soviet Union had only two large design offices, one for bombers and one for fighters, and each of them had a monopoly in its field. In spite of the outstanding qualities of the aviators who headed these offices, namely A. N. Tupolev and N. N. Polikarpov, for a country as large as the USSR two design offices certainly were not sufficient. Admittedly, at that time there were some other small groups of designers, but most of them had hardly any influence on the development of Soviet aviation.

Finally, the most important aircraft plants were situated in the European part of the USSR. Further, most of them were located between the western border and the Volga. Only a minute number of aircraft plants beyond the Volga proved to be outside the range of enemy bombers. Although the front was in urgent need of aircraft, their production had to be almost stopped for a time, because it was essential to evacuate the plants to Siberia.

Only the great moral and physical strength of the Soviet people saved the Soviet state in its desperate situation. Firm solidarity with the Party and the huge industrial potential created by the people in the years of building a new life made it possible to overcome all the difficulties and to gain a great victory.

During the initial period of the war the employees of the aviation industry concentrated all their strength on liquidating the numerical superiority of the German air force within the shortest possible time, to replace the losses suffered in the first days of the war, and principally to develop as quickly as possible production of new fighters to achieve air supremacy. It was not only necessary to organize quickly the evacuation of the plants, but also to prepare simultaneously bases in the East to receive people and equipment and to start production for the front.

Thousands of trains transported equipment of aircraft plants across the Volga, to the Urals, to Siberia. Sometimes equipment and people were loaded onto trains at the climax of enemy air raids, but this did not stop evacuation. Furthermore, while some plants were engaged in loading, they continued producing aircraft. Each machine was dismantled at the last moment, and only after the parts for the stipulated number of aircraft had been produced. Then the assembly departments completed the aircraft and turned them over to the military pilots directly at the plant aerodromes. The staffs of the plants worked round the clock. Designers, together with workers and administrative staff, helped with the loading, taking care that the expensive and breakable equipment of design offices and laboratories arrived safely. Every foreman and worker, every designer endeavored to take all that was necessary so that production could be resumed immediately upon arrival at the new place.

The move beyond the Volga, to the Urals, to Siberia required new cooperation, new lines of flow of goods transport, and this complicated the situation even more.

Transports of industrial equipment alternated with military ambulance trains and passenger trains carrying evacuees. Often precedence had to be given to ambulance trains or to trains which evacuated people from the fighting zone to the East. All this created enormous difficulties for the railroads, not only involving the passage of an innumerable amount of trains but also the organization of feeding and even the provision of most elementary services for the large number of people at the railroad stations.

When frost set in and snow began falling, the difficulties became even greater; nevertheless, the task was brilliantly fulfilled.

The people showed great heroism when, on arriving in winter at the eastern districts, at the new places, they resumed plane production within a short time. In Moscow loading of trains was still in progress, and in the East preparations were already being made to receive people and equipment. Plans for locating departments were made, and mains installed for electric power, compressed air, steam, water—everything was done so that the arriving machines could immediately start working.

By January or February 1942 the evacuation on the whole was completed, and the evacuated aircraft plants resumed series production of engines and planes within an exceedingly short time.

In March 1942 output of aircraft had already increased, and their supply to the front improved. As the Soviet pilots became familiar with the new planes, they convinced themselves in aerial combat of the preponderance of Soviet aviation technology. Considerable numerical superiority, however, remained on the side of the German Luftwaffe.

In defensive fighting the might of the Soviet air force grew. It helped actively to defeat the Germans outside Moscow, thereby also shattering the myth of German invincibility. Even more active was the role of the Soviet air force in the battle of Stalingrad.

In the early stages of the battle of Stalingrad in the middle of July 1942, the Germans in support of their ground forces brought in large forces of their aviation, particularly the 4th Air Fleet.

In this section the German command concentrated more than twelve hundred planes. The German aviation was three or four times stronger numerically than the Soviet aviation. Moreover, the Soviet 8th Air Fleet,

which defended the city, was three-fourths equipped with obsolete planes, and there were very few new planes.

In the fall of 1942 the government Committee of Defense decided to greatly increase the output of fighter planes. The Soviet command also created new units within the framework of the 16th Air Fleet. These units were staffed by the best fighter pilots who were experienced from fighting the Germans near Moscow and elsewhere. Soviet pilots won many victories, demoralizing the German pilots, and young Soviet flyers found that the Soviet machines in the hands of skilled soldiers were decidedly better than the enemy's.

Terrific damage was inflicted on the German ground forces by the Il-2 attack planes, which were produced in constantly increasing numbers. At night the German forces were harrassed by low-powered U-2 (Po-2) planes.

In the aerial battle over Stalingrad the Soviet air force and anti-aircraft artillery destroyed or damaged 929 enemy planes. The German losses were so great that they had to transfer to the battle zone air force units from faraway, including the 8th Air Corps, which was directly subordinated to the German High Command, and even air force units from Sicily. The Germans were also obliged to transfer to Stalingrad some air force units from Leningrad and the central front. Yet even that did not help them. The sky over Stalingrad became a huge meat grinder of German aviation.

On 2 February 1943 the encircled group of Field Marshal Paulus' forces capitulated. The Germans had suffered a disastrous defeat from which they never fully recovered. The German air force, too, did not recover from the blow. Greffrat wrote: "... the German Air Force suffered great losses in the operations near Stalingrad. Between 19 November and 31 December 1942 the Germans lost about three thousand planes. This number includes, in addition to planes that were shot down, also planes captured on airfields by the Russians. Also lost was an enormous amount of ammunition and material."*

General Dörr admitted: "Not only the ground forces, the air force, too, lost an entire army at Stalingrad."**

The turn in the fate of Soviet aviation that occurred during the battle of Stalingrad was not accidental. The output of planes produced by the Soviet aircraft industry increased daily. Production of fighters increased steadily during 1942, and in spring 1943 the Soviet airmen won a great victory on the Kuban, and thus established their air supremacy.

The considerable increase in the output of fighters made it possible to find novel solutions to many tactical problems of aviation. For example, the Il-4, the main long-range bomber of the Soviet air force, which had a maximum speed of 450 kph, could not, throughout the war, risk flying combat missions by day without a fighter escort. Since such escorts could not be provided at the beginning of the war, the Il-4s were mostly used at night. As soon as more fighters were supplied to the front, the question of flying daylight missions arose. It was also necessary to provide fighter cover for attack planes. It became absolutely necessary to equip the Yak-9 fighter with heavy 37-mm cannons and to increase the range of the fighters in general. The increase in the range of fighters, especially the La-5

* Mirovaya voina 1939—45 (The World War 1939—45), p. 481.

** Dörr, G. Pokhod na Stalingrad (The March on Stalingrad), p. 118.—Moskva, Voenizdat. 1957.

and Yak-9, was essential because the Supreme Command planned a large-scale offensive in summer 1943 and the rapid advance of the ground forces had to receive air cover.

By summer 1943 the Soviet air force had powerful planes and equipment at its disposal. The number of fighters was sufficient but were dispersed over an enormously long frontline. Under such conditions it was necessary to form large offensive fighter units capable of carrying out the attack operations the High Command had in mind. When this problem was discussed by the State Committee for Defense, it was noted that the Soviet fighter planes were dispersed to different fronts and could not be used, concentrated into a powerful force, for independent tasks, e.g., gaining air superiority at a certain sector of the front. As long as the fighters cooperated with the ground forces, they did not have an independent role. The aerial battle over the Kuban showed, however, what fighters can do when they are bunched like a fist and purposefully used.

It was proposed to form several specialized fighter units directly subordinated to the Supreme Command and to use them for massed air strikes against enemy aviation.

Such organizational measures soon proved justified in view of the heroic work of the huge army of workers and engineers. The Soviet aircraft industry grew in the Volga region and in Siberia, and several plants were restored in the former frontline area. Teams of local and evacuated specialists worked well together in aircraft plants. There was a broad movement, covering the entire Soviet Union, of socialist emulation of workers, administrative and technical employees of the aircraft industry. The greatest successes were achieved by plants headed by outstanding managers, such as S. I. Agadzhanov, M. S. Zhezlov, V. N. Lisitsyn, A. T. Tret'yakov, A. A. Belyanskii, I. S. Levin, M. S. Komarov, and chief engineers A. N. Ter-Markaryan, A. A. Kuindzhi and others.

By the middle of 1943 the Soviet air force had already twice as many planes as the German Luftwaffe. "Average monthly output of aircraft rose from 2100 in 1942 to 2900 in 1943. In 1943 the aircraft industry supplied altogether about 35,000 planes, i.e., 37.4 percent more than in 1942.

"Engine plants in 1943 produced 49,000 aircraft engines, almost 11,000 more than in 1942."*

The aircraft industry did not only increase the output of machines. The year 1943 also saw the struggle for better flight and tactical properties of the aircraft in production. The Soviet air force received the La-5, Yak-9 and Yak-3.

During the war it was found that the LaGG-3, weighing more than 3 tons, had an insufficiently powerful engine. The designer therefore powered it more with an air-cooled radial engine, first a 1700 hp, ASh-82, then a 1850 hp, ASh-82FN. The planes with these engines were the La-5 and La-5FN. Further improvement of the aircraft could not be achieved by increasing engine power but by reducing the weight of the structure and improving the shape, reducing losses on cooling and sealing the power plant (which is particularly important in air-cooled engines). As a result maximum speed was raised to 650 kph, and rate of climb and maneuverability were improved. Lavochkin's fighters had powerful armament: the La-5 had

* Istoriya Velikoi Otechestvennoi voiny Sovetskogo Soyuza (History of the Great Patriotic War of the Soviet Union), Vol. 3, p. 167.

two and the La-7 had three synchronized 20-mm cannons firing through the plane of rotation of the three-bladed propeller. The sturdy radial engine made the aircraft less vunerable and provided a certain measure of protection for the pilot against fire from the front. Lavochkin's fighters also excelled by easy control and good maneuverability, especially in steep banking, and their flight and tactical characteristics were better than those of the German FW-190 and Me-109 fighters.

The Yak-9 appeared at the front at the time of the Stalingrad battle. At first it had a VK-105PF, 1240 hp engine, later a VK-107A, 1650 hp engine, and the speeds attained by the aircraft were 605 kph and 700 kph, respectively. The Yak-9T fighter carrying 37-mm and 45-mm cannons was successful not only against enemy aircraft but also against ground targets. When the Soviet army began its attack, it was necessary to increase the range of fighter planes. The answer was the Yak-9D and Yak-9DD with ranges of 1400 km and 2200 km, respectively, and the reconnaissance plane Yak-9R. The Yak-9B was, in this series, the only high-speed fighter-bomber with 400 kg of bombs carried in the fuselage.

In 1943 the lightest and most maneuverable fighter of World War II, the Yak-3, was developed from the Yak-1. It weighed 2650 kg. Its aerodynamic shape was a radical improvement, and all its parts were subjected to close scrutiny. Since metal production in the Soviet Union had risen, it was possible to replace the heavy wooden wing spars by aluminum ones. The oil radiator, originally below the fuselage, was mounted onto the wing, the water radiator was made completely flush with the fuselage, the shape of the cockpit was improved, and the tail wheel was made retractable. The wing area was reduced from 17.15 m^2 to 14.85 m^2. With a VK-105PF engine the Yak-3 had a speed of 660 kph, and with the new VK-107A engine this was raised to 720 kph. Because of its perfect streamlining, lower wing loading and power loading than that of the later modifications of the Me-109 and the heavy FW-190, the Yak-3 had higher speed, better rate of climb, and better vertical and horizontal maneuverability. The summing up by the Scientific Research Institute of the Air Force states that the Yak-3 with the VK-107A engine "in regard to its flight specification and at heights from ground level to its service ceiling is better than any known Soviet or foreign fighter."

The bombers were also improved. Ilyushin developed the Il-2 into a new all-metal, two-seater attack plane, the Il-10, with a more powerful AM-42 engine, 2000 hp, and stronger armor. Its speed was 551 kph and its armament was the same as that of the Il-2. Ilyushin's attack planes were a terrifying weapon of Soviet aviation. They struck terror in the enemy's heart and were called the "black death" by the Germans.

In the fall of 1943 mass production started of Tupolev's Tu-2 bomber, after it had passed its government tests and had been produced in a short production run. This tactical bomber with two air-cooled ASh-82FN engines of 1850 hp had a maximum speed of 547 kph at an altitude of 5400 m. At the normal take-off weight of 10,380 kg the bomb load was 1000 kg, and the overload version of this plane could carry up to 3000 kg of bombs. The instruments of the Tu-2 permitted level bombing and dive-bombing, both with precision. In addition, the aircraft was equipped with two 20-mm cannons and three defensive 12.7-mm machine guns. The Tu-2 had a crew of four. Its normal range was 2100 km. The tactical and flying characteristics of the Tu-2 were better than those of the German Ju-88 bomber.

As early as 1942 the Soviet aviation outstripped the Germans. In 1942 Germany produced 14,700 planes while the USSR produced 25,400. In 1943 Germany produced 25,000, the Soviet Union 35,000. Within these two years the Soviet army thus received 20,000 planes more than the German army.

Hence the Soviet air force surpassed the German Luftwaffe quantitatively, regarding the number of planes. This, too, was brilliantly confirmed in the battle of Kursk.

In the battle of the Kursk bulge the Soviet air force fully utilized its air superiority. The German ground forces suffered huge losses. Frightened by the courage of the Soviet pilots and aware of the qualities of Soviet fighters, the Germans avoided dogfights, even when they had momentarily numerical superiority in planes. Orders by the enemy command have been preserved which categorically forbid engaging Soviet fighters, especially the modernized ones.

In an article entitled "The Aviation of the Offensive" (Aviatsiya nastupleniya) General S. I. Rudenko, the commander of the 16th Air Fleet, which excelled in the battle of the Kursk bulge, wrote as follows about the results of these historic air battles:

"Here are some figures characterizing the work of the air force in one day of the Orel-Kursk operation in summer 1943. Within one hour, between 1200 and 1300 hours, a massed strike of 411 planes was carried out, between 1530 and 1630 hours 444 planes went into action, and the final strike between 1900 and 2000 hours saw 460 planes in action...

"Conclusions.

"Firstly, the increased numerical strength of the Air Force enabled us at that stage of the war to carry out many massed air attacks against German arms and troop concentrations. Thanks to that the Soviet aviation not only supported the ground forces but played a decisive part in ensuring victory.

"Second conclusion. The high skill of the fighter pilots' flying planes, such as the Yaks and LaGGS, and the pilots' having learned brilliantly to change altitude in combat, enabled us to beat the enemy in the air. Whereas after Stalingrad we could say that the initiative passed into our hands, after the battle of Orel and Kursk we say that our aviation is firmly on the way to complete supremacy."*

As a result of the battle at Kursk the German army found itself on the brink of disaster.

After the liquidation of Paulus' army some German commanders and especially Hitler himself, still cherished hopes of reversing the situation by exacting revenge in the Kursk bulge, but after the crushing defeat there no hopes remained for the Germans of winning the war. The destruction of the German forces at Kursk foreshadowed Germany's defeat. The initiative, both on the ground and in the air, had passed fully and incontrovertibly to the Soviet army.

The Nazis retreated, endeavoring to conserve their strength, to withdraw in order to new lines, as the fascist newspapers wrote, "to straighten out the front" and "to organize an elastic defense." The task of the Soviet forces was then to encircle, destroy and not permit them to withdraw "in order."

To break the enemy and then to finish him off in his own den, such was the task given by the Soviet command. This also called for changed tactics in

* Krasnaya Zvezda, 19 August 1944.

the air. The Soviet air force now endeavored to prevent the organized withdrawal of the desperately struggling enemy, to destroy him at crossings.

Forever gone was the time when German fighters and bombers could appear in the sky in small groups or even singly. Now they could not dare do such a thing. Afraid of the Soviet fighters, the German bombers now appeared only under the menacing protection of Messerschmitts and Focke-Wulfs.

Sometimes the German forces retreated so fast that the Soviet units servicing aerodromes in the rear did not have time to prepare new aerodromes for the attacking forces. This belated organization of aerodromes for fighters caused various difficulties when the Soviet army was about to cross rivers, and it was particularly felt in the crossing of the Dnieper.

The German air force tried with all means at its disposal to prevent the Soviet forces from crossing the Dnieper in their westward advance. The Russians tried to cross the Dnieper straight away as soon as they reached it and not to give the Germans time to fortify the right bank. Thus the Russians upon crossing came under furious attacks by German attack planes, fighters and bombers. The Soviet fighters were limited by their range and by a lack of forward airfields which had not been prepared, and therefore they could not provide the required support for the troops crossing the river. Hence the Soviet government raised the question of increasing the range of Yak and La fighters within the shortest possible time.

This was achieved.*

After the Soviet forces had cleared the Germans from the banks of the Dnieper, the air force was charged chiefly with pursuing and destroying the retreating enemy. The Soviet air force cooperated with the ground forces in the fighting for Kiev and in the operations of encircling the Korsun-Shevchenko grouping. It destroyed enemy aircraft in the air and on the ground. Within only three months of 1945, from January to March, about four thousand German combat planes were destroyed.

The war moved into the enemy's territory. The end was near. The Germans fought desperately and tried to slow down the advance of the Soviet forces toward Berlin, but they had little success.

In Silesia the Soviet airman actively supported the ground forces. Here they met modernized Focke-Wulfs and beat them just as mercilessly as they had recently destroyed the Messerschmitts-109 over Soviet territory.

In East Prussia the Soviet air force dealt the Germans crushing blows. On 17 April 1945 the bombers of the 18th Air Fleet under Chief Air Marshal A. E. Golovanov in the area west of Königsberg flew 516 sorties within forty-five minutes and dropped a total of 3743 bombs.

At the approaches to Stettin the Germans tried with full force to stop the Soviet advance such that their retreating forces could cross the Oder, but the Soviet planes at that time hovered constantly above the German crossings.

In the Berlin area Hitler collected all his remaining forces in the hope of avoiding unconditional surrender. All these hopes were dashed.

* At the beginning of 1944 a group of Soviet pilots in Yak-9DD fighters flew nonstop from the USSR to Italy over German-occupied Rumania, Bulgaria and Yugoslavia. This flight took place in daylight, in full view of the enemy who was powerless against the Soviet high-speed fighters. This flight to the port of Bari on Italian territory liberated by the Allies was organized according to instructions by the Soviet government to render assistance to the Yugoslav army of national liberation.

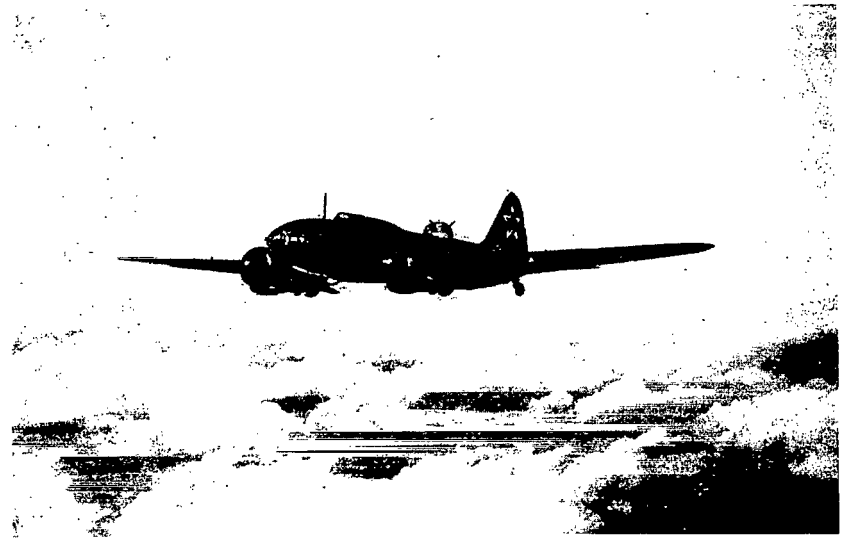
Combat aircraft in World War II

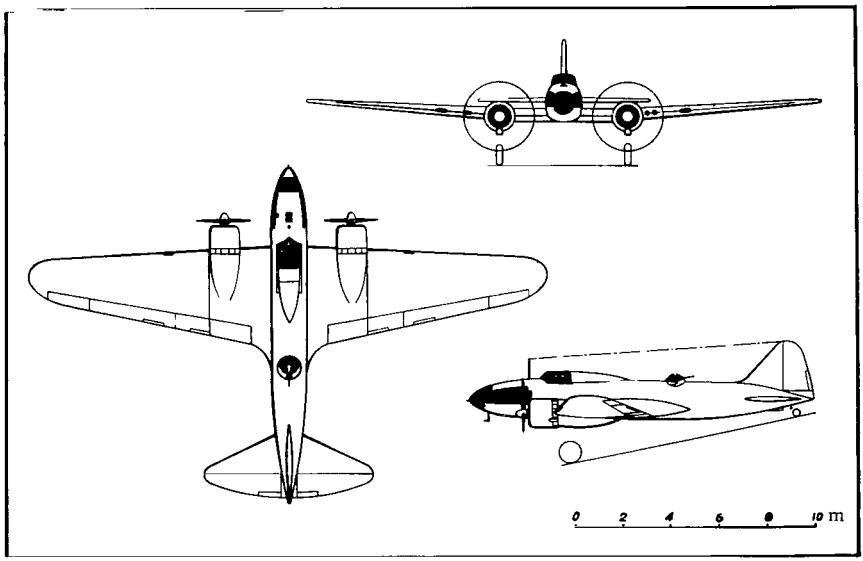
Type of aircraft	Year of production	Engines (type, number, power)	Take-off weight, kg	Armament and bomb load	Crew	Maximum speed, kph	Range, km	Altogether produced
Il-4	1938	M-88B, 2 x 1100 hp	10,055	1 12.7-mm machine gun; 2 7.62-mm machine guns; 1000 kg of bombs	3	445	3800	1528 DB-3 5256 IL-4
Pe-8	1939	AM-35A, 4 x 1350 hp ASh-82FN, 4x1850 hp	32,000	2 20-mm cannons; 2 12.7 mm machine guns; 2000 kg of bombs	8—12	440 450	4700 6000	79
Il-2	1939	AM-38F, 1750 hp	5873	2 23-mm cannons; 2 7.62-mm machine guns; 400 kg of bombs; 1 12.7-mm machine gun	2	420	765	36,163 Il-2 4966 Il-10
Pe-2	1940	M-105R, 2x 1100 hp	8520	3 12.7-mm machine guns; 2 7.62-mm machine guns; 600 kg of bombs	3	540	1200	11,427
Yak-1	1940	M-105P, 1050 hp	2895	1 20-mm cannon; 2 7.62-mm machine guns	1	580	850	8721
MiG-3	1940	AM-35A, 1350 hp	3350	1 12.7-mm machine gun; 2 7.62-mm machine guns	1	640	1250	100 MiG-1 3322 MiG-3
Yak-9	1942	VK-105PF, 1240 hp	3060	1 37-mm cannon; 2 12.7-mm machine guns	1	605	1000	6399 Yak-7 16,769 Yak-9
La-5	1942	ASh-82FN, 1850 hp	3230	2 20-mm cannons	1	648	765	6528 LaGG-3 10,000 La-5 5753 La-7
Yak-3	1943	VK-105PF, 1240 hp	2650	1 20-mm cannon; 2 12.7-mm machine guns	1	660	900	4848
		VK-107A, 1650 hp	2984	2 20-mm cannons		720	1060	
Tu-2	1943	ASh-82FN, 2x 1850 hp	10380	2 20-mm cannons; 3 12.7-mm machine guns; 1000 kg of bombs	4	547	2100	2527

In the air battle for Berlin the Germans put into action everything that remained of their beaten air fleets, of the formerly so proud and invincible Luftwaffe. The motley German air fleet was based on approximately forty airfields around Berlin. In the aerial fighting it was not a rarity for one thousand planes on both sides to participate. On the first day of the Berlin operation the Soviet airmen flew 17,500 sorties, although the weather was not favorable. The superiority of the Soviet aviation was complete, the remainder of the Luftwaffe was crushed.

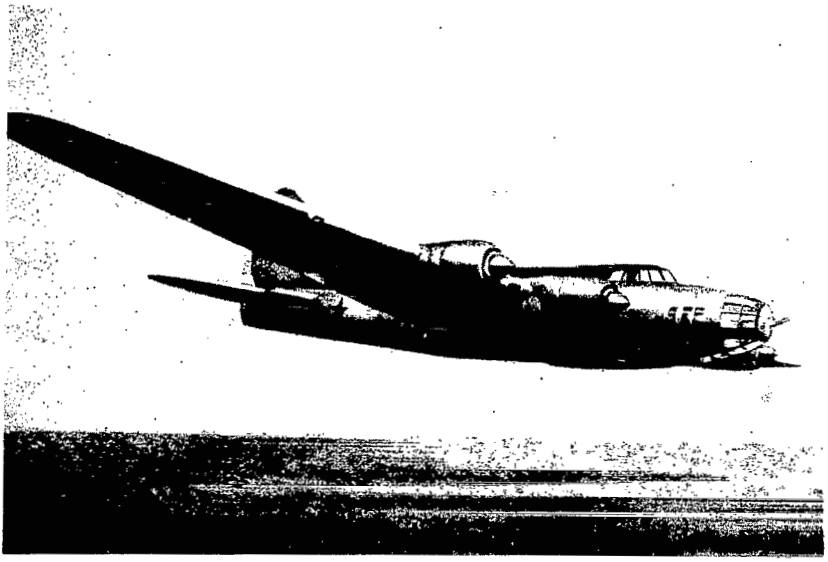
Near Berlin the Soviet airmen met German jet aircraft for the first time. However, as a dispatch from the battlefield to Pravda of 2 May 1945 said, "these unique jet-powered fighters did not help the Germans at all." The Soviet airmen quickly found the weak spots of the enemy aircraft and shot them down.

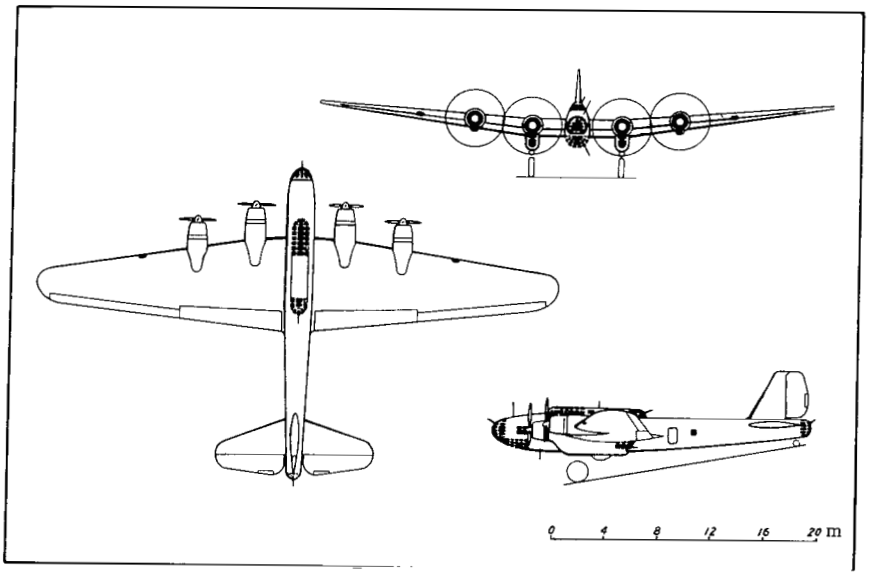
In the battle of Berlin the Luftwaffe was destroyed. Several thousand planes, which the Soviet airmen did not manage to destroy in the air or on the ground, were captured.



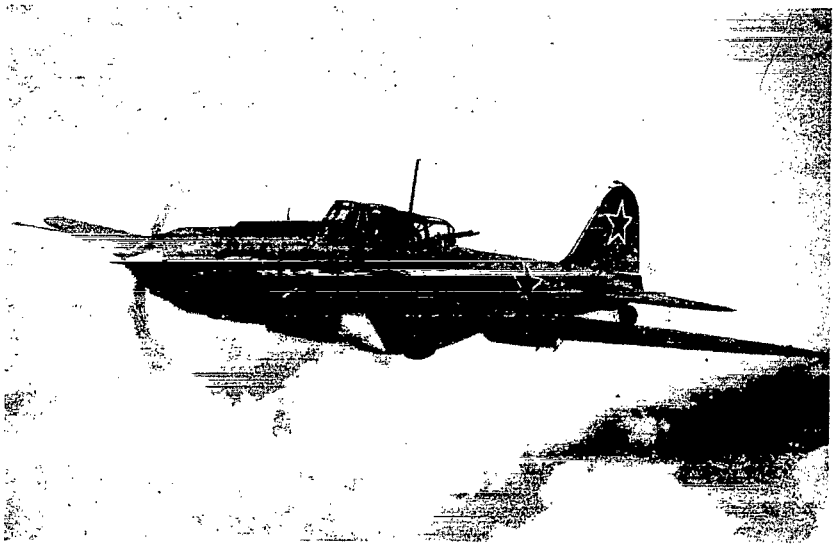


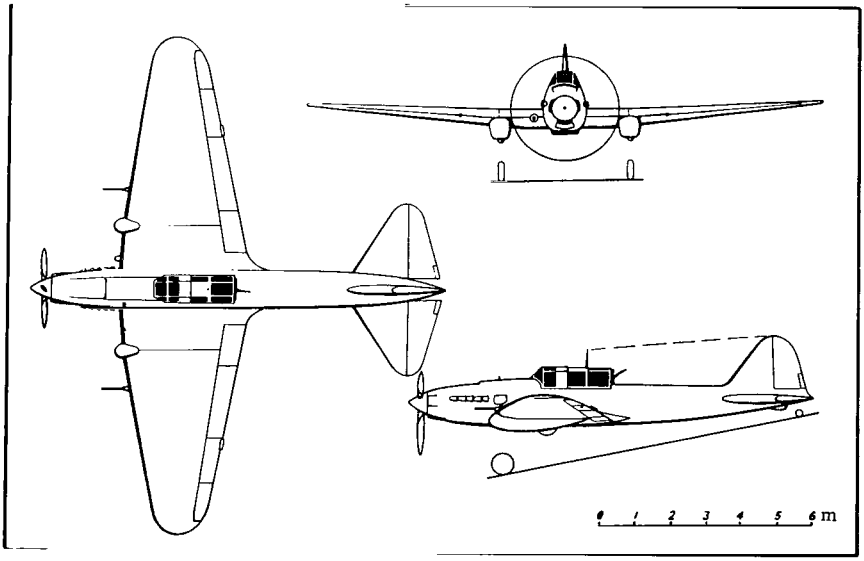
Long-range bomber Il-4, 1938.



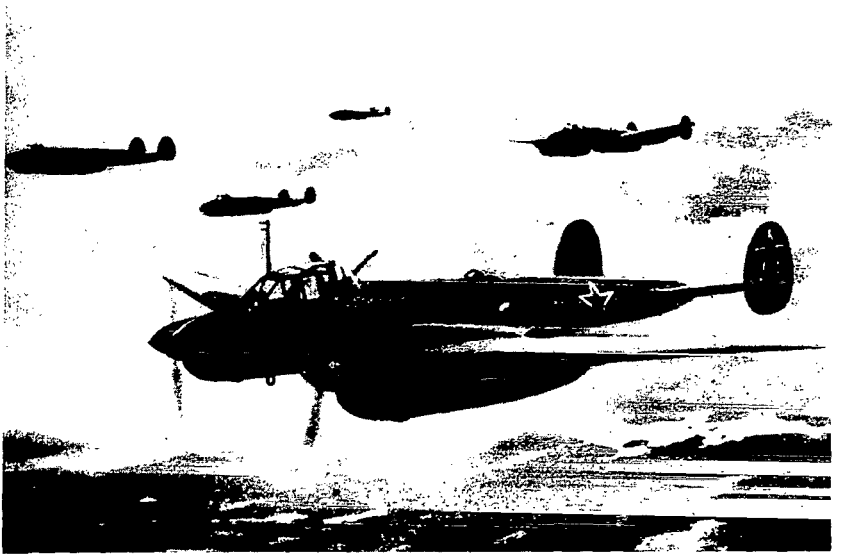


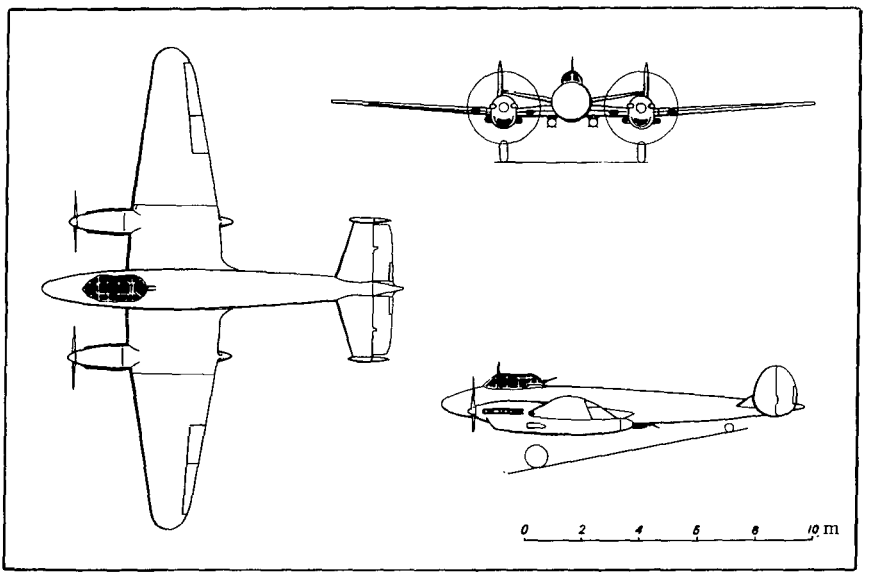
Long-range bomber Pe-8, 1939.



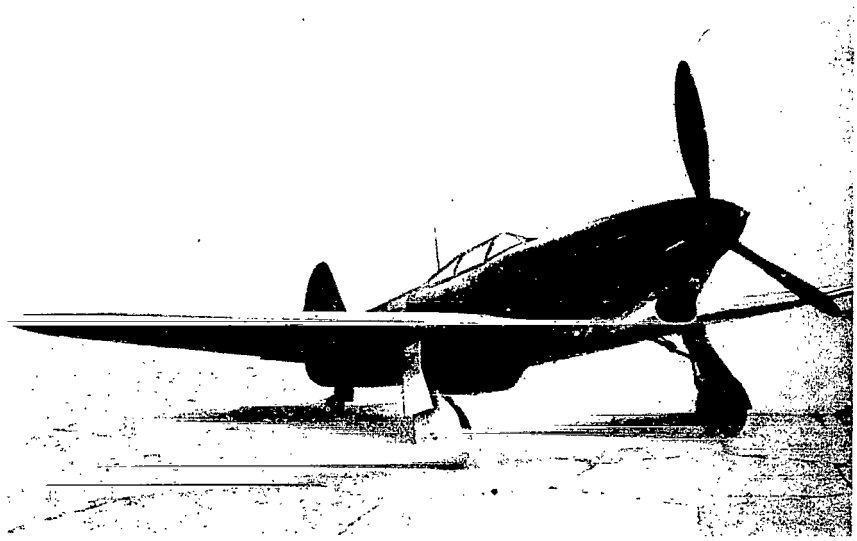


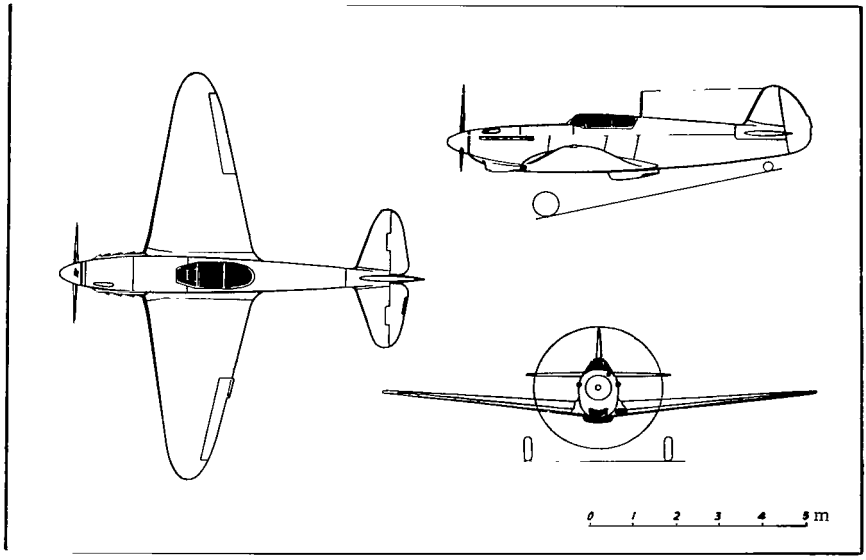
Attack plane Il-2, 1939.



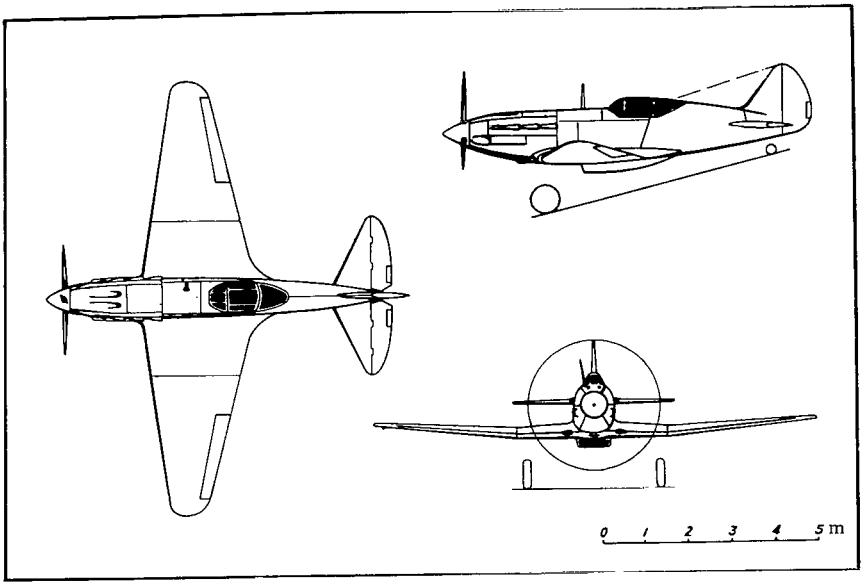


Frontline dive-bomber Pe-2, 1940.

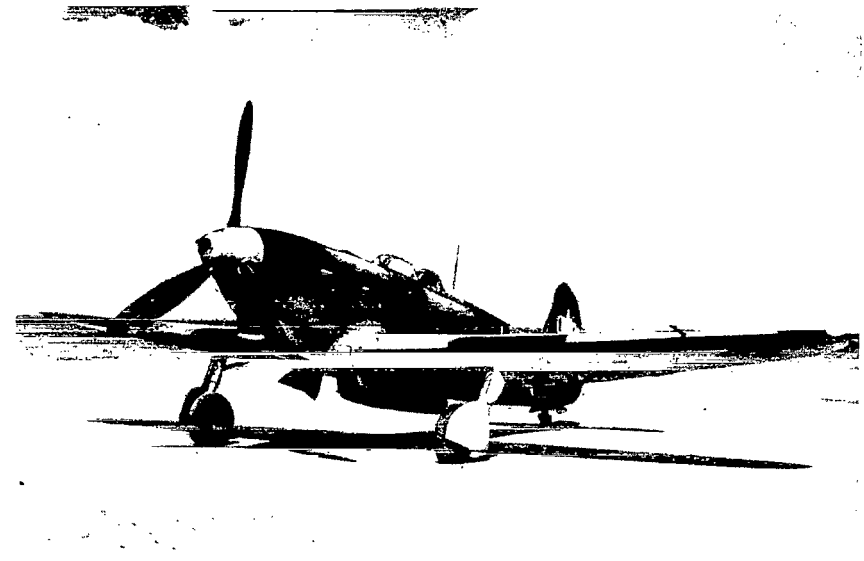


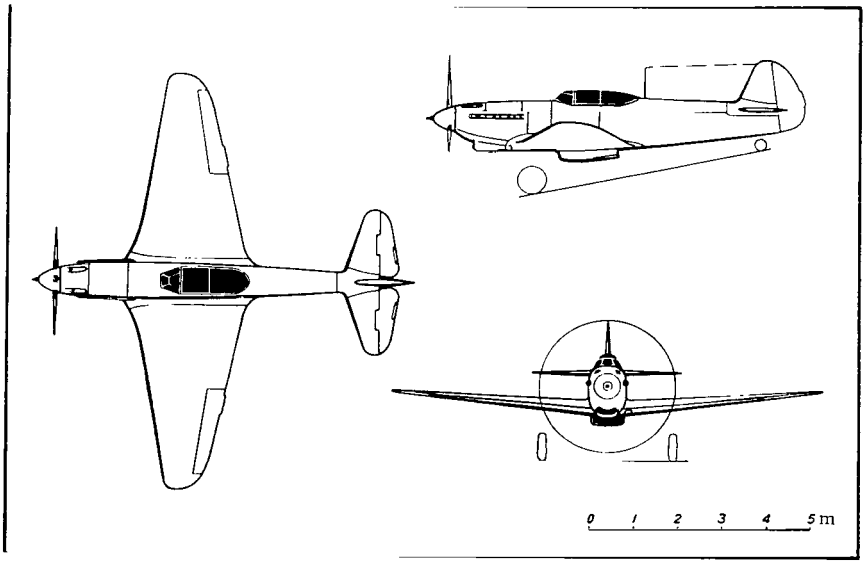


Fighter Yak-1, 1940.

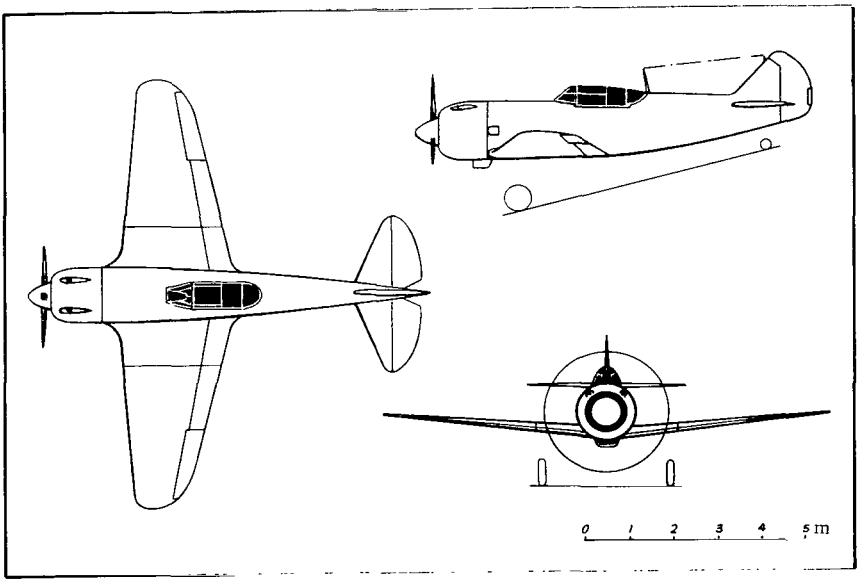


Fighter MiG-3, 1940.

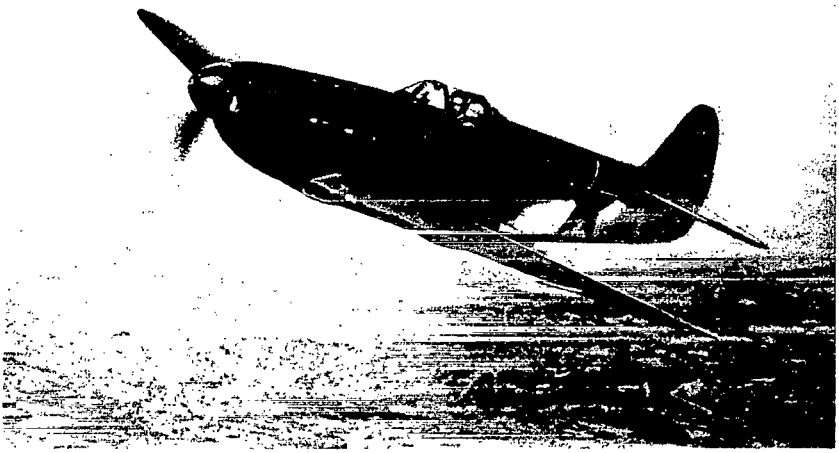


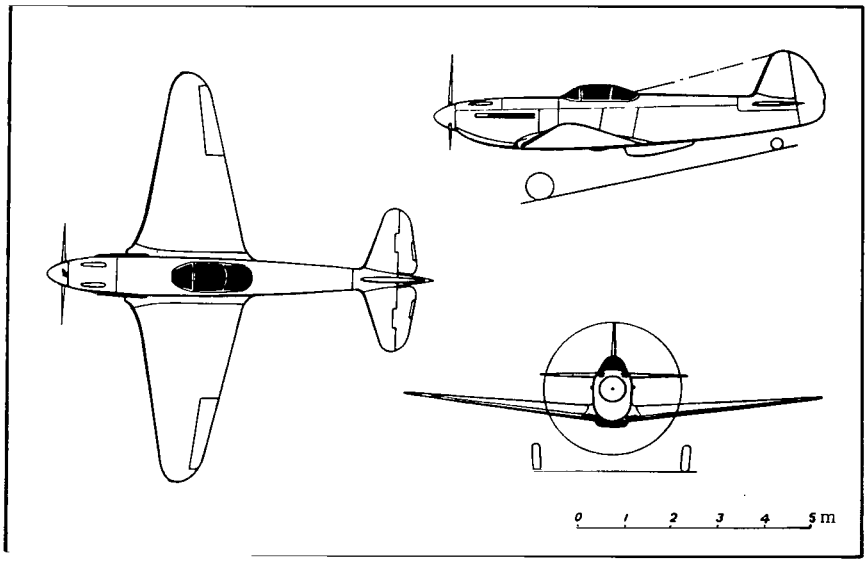


Fighter Yak-9, 1942.

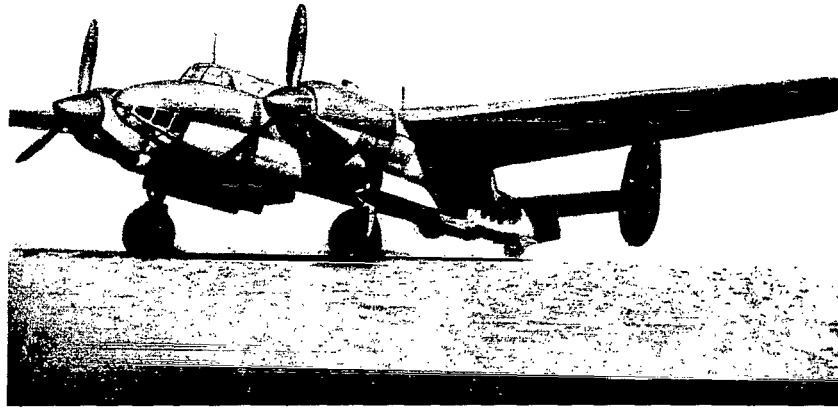


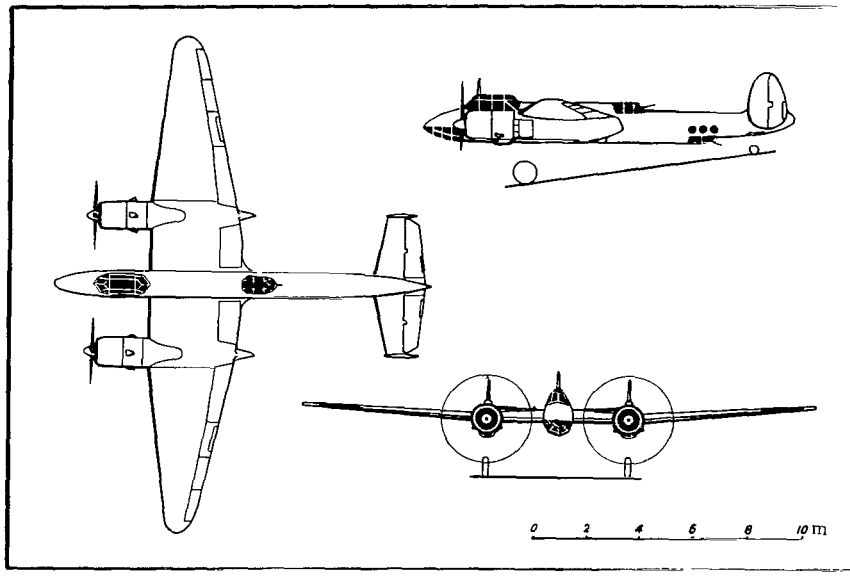
Fighter La-5, 1942.





Fighter Yak-3, 1943.





Frontline dive-bomber Tu-2, 1943.

5. *AVIATION OUTSIDE THE SOVIET UNION*

The successes achieved by Soviet aviation at the fronts of World War II are particularly striking if we compare the technical level of the enemy air force with the Soviet air force.

Nazi Germany had first-class combat planes at the outbreak of World War II. During the war the German Luftwaffe lost its superiority to the Soviet air force, both in quantity and quality.

At the Soviet-German front the German airmen suffered a decisive defeat.

The Anglo-American air forces had a powerful fleet of heavy bombers and they carried out massed air raids against the enemy rear, but the production potential of Germany and the output of armaments, especially aircraft, remained on a high level throughout the war.

The Soviet airmen, flying combat aircraft of high quality, absolutely defeated the German air force. The quality of the Soviet technical standard, however, can only be assessed correctly if the air forces of the Soviet Union's enemies and allies are also briefly described.

In the war against the Soviet Union the Nazis assigned their aviation a special task, and at that time the Luftwaffe had complete air superiority in the West. In principle the Germans planned to use their aviation the same way they had used it in the West: first gain air superiority and then move the forces wherever the ground forces require support.

The Germans looked with disdain upon the approaching battles with the Soviet airmen. They did not consider the Soviet aviation a match; they though it "Asiatic," unstable to stand up to the "invincible" Luftwaffe.

The German command fixed the day of the invasion of the Soviet Union for 22 June 1941 and charged the Luftwaffe with the following tasks:

1. To attack suddenly Soviet aerodromes to paralyze Soviet aviation.
2. To achieve complete air superiority.
3. After having fulfilled the first two tasks, to use the aviation for support of the ground forces directly on the battlefield.
4. To interfere with Soviet transport, hamper troop movements in the battle zone and as far as possible in the rear.
5. To bomb large industrial centers: Moscow, Gorki, Rybinsk, Yaroslavl, Kharkov, Tula.

It must be admitted that the Germans managed to fulfill their plans for aerial warfare extensively in 1941 and early 1942.

The Germans put into action against the Soviet Union almost all their aerial strength, including units transferred from the Western front. It was assumed that after the first successful strikes part of the bomber and fighter units would be returned to the West to fight against Britain.

At the beginning of the war the Germans did not have only numerical superiority. They had the added advantage that their pilots who participitated in the attack on the Soviet Union had had already much combat experience against French, Polish and British planes. In addition they

also had considerable experience in cooperating with their own ground forces, gained in the fighting against West European countries.

The German airmen, who at first met in combat only obsolete Soviet aircraft, were surrounded with an aura of invincibility by Goebbels' propaganda. However, already in 1942 more and more modern Soviet-built aircraft appeared, and the Germans' fame began quickly to diminish, until it became completely unfounded. Even in the first phase of the war the Germans lost a large number of airmen. They had to fill the manpower gaps by hurriedly trained young airmen who had no combat experience.

Throughout the war the Germans did not introduce any fundamentally new types of aircraft. They improved their planes' flight and combat characteristics by increasing the power of existing engines, by improving the aerodynamic shape of aircraft, by using stronger weapons and reinforcing armor, but this inevitably led to increased weight of the aircraft. Together with a certain gain in speed and firing power, it impaired the take-off and landing characteristics and the maneuverability of the planes. The improvements on German planes during the war were marked by a sense of emergency and hurriedness, because the Germans were forced to carry them out only when they recognized the actual power of Soviet aviation. When they started their war against the Soviet Union, they were convinced of the backwardness of Soviet technology. In his postwar work "Aerial Warfare" the German historian Greffrat stated:

"The representatives of the Luftwaffe High Command had to ask themselves one serious question: how correct was their assessment of the Russian aviation, regarding quality and chiefly regarding numbers? A great surprise for the Germans was, for instance, the appearance of the Russian Il-2 attack planes... .

"The Germans considered the combat ability of the Russian air force to be limited on the whole. Of course this did not exclude the possibility that in the course of time the Russians might overcome their weakness, but everybody was convinced that the fighting capacity of the Russian aviation would grow at an "Asiatic" pace, i.e., badly organized."*

The Nazis assumed that their aircraft park was sufficient, in quality and quantity, to permit them to wage the campaign against the Soviet Union as envisaged in "Plan Barbarossa," i.e., for five or six weeks.

Greffrat again wrote:

"Expecting the war in Russia to be the same kind of blitzkrieg as in the West, Hitler intended to return some bomber and fighter units to the West, after having achieved his first successes in the East. He planned to keep in the East only air force units for direct support of ground troops, some transports and a certain number of fighter squadrons. In reality everything worked out quite differently."**

In the initial phase of the war the German aircraft industry produced three basic types of combat aircraft: Me-109, Ju-87, and Ju-88, and the transport plane Ju-52. There were other aircraft produced in small numbers: the twin-engined heavy fighter Me-110, which was not successful; the obsolete He-111 and Do-217 bombers; and the FW-189 reconnaissance planes, called by the Russian soldiers rama (frame). When the ramas appeared, the bombers could be expected to follow soon.

* Mirovaya voina 1939—45 (The World War 1939—45), p. 474.

** Ibid., p. 469.

Because of their numerical superiority, these planes were able at first to inflict considerable damage. Since the Russians were short of fighters, they could drop their bombs with impunity both day and night. At this time the Germans thought that the main task of their aircraft industry was to produce the largest possible number of planes. Not until late in summer 1942, after having to contend with the steadily improving quality and numerical strength of Soviet aviation, did they change their approach and begin feverishly to prepare the modernization of their aircraft, bombers and fighters. But it was too late. Neither their designers nor their aircraft industry was a match for the Soviet Union any longer.

At the time Germany attacked the Soviet Union, the backbone of its air force were the Me-109 fighters, which had been on combat duty since 1937.

In the first two years of the war in Europe the first version of this aircraft, the Me-109E, was used. This aircraft was not being modernized. There was no particular need to do so, because for a long time its flight and tactical characteristics were as good as those of the British planes. The necessity of modernizing the Me-109E arose only in 1941 when the Germans encountered new Soviet aircraft and improved British planes.

The result was the appearance of the Me-109F in spring 1942. The difference between it and the original version was chiefly an improved aerodynamic shape, a more powerful engine and more powerful armament. The new aircraft was used in large numbers in the battle near Kharkov in June. Even it, however, was not equal to the best Soviet planes. Another more advanced aircraft was therefore built, the Me-109G. It appeared first at the end of August over Stalingrad.

Each modification of the Messerschmitt — the 109F, 109G, 109G2, 109G4, and others — brought about some improvement in the tactical characteristics of the aircraft. However, every improvement meant an increase in weight. In the end the originally light and excellent Me-109 weighed almost 3.5 tons and lost its maneuverability. In spite of the increased engine power and improved armament, the Germans did not succeed in endowing their Messerschmitts with any qualities that would make them superior to the Soviet Yaks or Las.

In different modifications the Me-109 was in service throughout the entire war. Still the Germans believed that they needed another fighter to support the Messerschmitts and, after having started the war against the Soviet Union, they produced Kurt Tank's fighter, the Focke-Wulf-190, powered by a 1650 hp, air-cooled radial engine BMW-801, unlike the Messerschmitt with a Daimler-Benz engine.

The first report on the appearance of the new enemy fighter, the Focke-Wulf-190, was published in the paper Krasnaya Zvezda on 7 May 1943. It was an event that the Soviet airmen did not expect. The plane looked quite different from the Messerschmitt.

The Focke-Wulf-190 was 20 kph or 30 kph faster than the Me-109, but it was much heavier and less maneuverable. The German fighter pilots derived practically no advantage from it.

At first the Focke-Wulf-190 carried four machine guns. In the course of the war the Germans added another two weapon emplacements and provided front and belly armor. These "improvements" raised the weight of

the plane to 4 tons, further impairing the maneuverability and take-off and landing characteristics of the Focke-Wulf-190.

Among the German bombers the He-111 must be mentioned first. It had a Daimler-Benz-601 engine and was supplied to the Luftwaffe in 1936. Several improvements succeeded in raising the speed of the plane from 310 kph to 400 kph. Although the plane had strong defensive firearms, it was as a rule shot down by Soviet pilots because of its low speed, unless it was provided with powerful fighter cover.

A better bomber was the twin-engined Ju-88; but when the Soviet aircraft industry began supplying the front with sufficient numbers of new fighters, the Ju-88 could not risk raiding either without fighter cover.

Finally, there was the Ju-87, a single-engined two-seater dive-bomber, a fairly slow plane. It was useful only where it did not meet opposition by fighters, e.g., in Poland, France, and also at the beginning of the war against the USSR when there were few fighters available. The Germans at first endeavored to use the dive-bomber Ju-87 as an attack plane, but it did not have any armor and was incomparably inferior to the Russian "flying tanks" Il-2. By the end of the war these planes had almost disappeared from the Soviet-German front.

Dornier produced the Do-217 bomber. The Germans had great hopes for it. But it seemed strange: since there was a modern bomber available, the Ju-88, what could be gained by splitting one's forces and producing an almost identical plane, the Do-217? The only difference between the two planes was that one was made by Junkers and the other by Dornier and that the Ju-88 had a single tail unit, the Do-217 a twin tail unit. Otherwise, even externally, the planes were identical.

The Do-217 bomber was somewhat faster than the Ju-88, but on the whole it was not better. During the war the Do-217 was seen rarely at the Soviet front. It was not used much and the main type of bomber right to the end of the war was the Ju-88.

In the war against Poland and France the Junkers and Messerschmitts gained absolute superiority and were therefore put into mass production in all German plants. Later, after France had been defeated and other European countries had also been conquered, the Germans organized production of these aircraft in occupied countries.

At the beginning of the war the Germans mounted sirens on the Ju-87s. Their task was simply to frighten people. At the moment when they began diving, the pilots switched on these sirens which began to wail, almost imperceptibly at first, but then piercingly, increasingly louder as the aircraft approached the ground. The Germans used these planes in North Africa against British forces, terrifying the colonial soldiers.

In the second half of the war against the Soviet Union, the Germans not only removed the sirens but also the Junkers and Heinkels did not even risk appearing above the Soviet positions unless they could hide in the clouds. They endeavored to remain undetected as long as possible. When they encountered Soviet fighters, they were usually shot down.

Not everything that seems good before the war proves its worth when the shooting begins. Such was the case with the German fighter He-100. This plane was beautifully streamlined and faster than the Me-109 (650 kph vs. 570—580 kph). Concerning speed and maneuverability,

it had no equal at the outbreak of World War II. But what was the price Heinkel paid for the advantage in speed?

This plane powered by a water-cooled engine was deprived of normal radiators. The cooling liquid passed through a complicated system of heat exchangers situated in the double wing covering. Heinkel thus improved the aerodynamic shape of the plane, but its operation became too complicated. If a single bullet pierced the wing, the plane was disabled, whereas other planes returned safely to their bases with tens of bullet holes in them. In addition it was found that the He-100 could not fly in winter. The cooling system in the wings, operating on steam, froze. Several such planes, which found their way to the Soviet front, caused the Germans a lot of trouble.

Thus a plane, well conceived and with good flight characteristics, having great advantages against other fighters, turned out in wartime to be absolutely useless. Its slower competitor, the Me-109, was firmly entrenched in the Luftwaffe and operated from the first to the last day of the war.

The Me-109, built in 1936, was not immediately appreciated. It was not well received by the Luftwaffe command; but in spite of the opposition by Erhard Milch, the state secretary in the Ministry of Aviation, Messerschmitt managed to obtain an order for twenty Me-109s. This batch of fighters was sent to Spain. Under actual combat conditions there, the plane proved its good combat characteristics. Afterwards it was produced in larger numbers.

Another example is the propaganda the Germans made with the appearance of a diesel-powered Junkers bomber. The advantage of diesel engines is their economy; they need less fuel. Moreover, this fuel is cheap oil instead of expensive gasoline. It is no secret that Germany before the war was short of aviation fuel. Since the Germans had no oil of their own, they were forced to produce synthetic gasoline, and the possibility of using oil instead of gas was vital for them. This seeming advantage did not stand the test, either in experiments with prototypes or in operation. Consequently diesel engines were dropped by the German aircraft industry.

It is well known that the Germans always overrated their strength and underrated the enemy. For instance, in 1943 they pinned all their hopes for a successful offensive at Kursk on their new weapons, aircraft Focke-Wulf-190, Tiger and Panther tanks, and self-propelled guns, the Ferdinands. With their usual self-confidence they assumed that the new weapons would be better than the Soviet weapons and would secure victory in the air and on the ground. The fighting in summer 1943 proved that the Germans' confidence in their new weapons was unjustified.

Even at the first clashes the Focke-Wulfe-190 was no match for the new Soviet fighters. Soviet designers produced during the war such antitank guns and new tanks for which the vaunted German Tigers, Panthers and Ferdinands held no terror. On the other hand it must be admitted that the Germans succeeded in producing a few planes with jet propulsion, especially the Me-262. A few of them even appeared at the front in the last year of the war.

Goebbels' propaganda machine made much of the possibility of influencing events with their miraculous weapons. A legend was created about the wondrous secret weapon that would shortly force Britain to her knees and ensure German victory. This referred to pilotless aircraft.

The jet-propelled flying bombs V-1 and the ballistic rockets V-2, used to bomb London and other English towns, caused Britain much damage. England lost forty-two thousand persons as a result of attacks by V-1 and V-2. The Germans, however, did not succeed with their barbaric methods in breaking British morale or changing her strategic position.

The flying bombs and rockets had practically no effect on the course of the war in the West and certainly not on the final outcome.

Air raids on London and other cities, however, especially early in the war, were a calamity for the English. They had no fighters which could meet the German Heinkels and Junkers, escorted by Messerschmitts, at the distant approaches. The basic fighter of the British Royal Air Force at that time was the Hurricane with a speed of only 520 kph, i.e., 50 kph less than the Messerschmitt.

The only serious obstacle the German bombers encountered over British territory were anti-aircraft guns and a dense network of barrage balloons. These measures soon proved insufficient for defense; the German bombers almost always broke through and caused the British cities much damage. The worst hit were London and the large industrial center of Coventry.

The German raids forced the English to speed up fighter production, because fighters were the most reliable defense against air attack. However, mass production of fighters at that time was hampered by constant bombing. Thus the British started building underground factories.

As a result of far-reaching reorganization of production the British introduced fairly quickly the production of large numbers of single-seater Spitfire fighters which had a speed of 585 kph. The Spitfire was one of the best fighters of World War II. The British also started mass production of four-engined Lancaster bombers, enabling them to change from defense to attack against Germany in the air. The Spitfire fighters and Lancaster bombers formed the backbone of British air power in World War II.

British bombers at the beginning of the war, 1939—41, were heavy four-engined planes with a maximum speed of about 400 kph. With these planes the British carried out fairly ineffective raids on Northwest Germany, the Ruhr, Hamburg, and even on Berlin. They dropped comparatively small bombs, and the damage they inflicted on the German capital was negligible. Nevertheless, in every such raid the whole of Berlin went underground into shelters and the entire life of the city was paralyzed.

Great interest was aroused when a new bomber, the Mosquito, appeared on the Western front. It was a wooden twin-engined plane, as fast as the best fighters at that time, about 600 kph, and it had a long range. In size it was more like a fighter than a bomber, and it was therefore inconspicuous in flight. Manned by the best and specially trained airmen, the Mosquitoes inflicted enormous damage on the Germans: they penetrated deep into the German rear and almost unchallenged caused chaos.

Suffice it to say that in one thousand sorties of Mosquitoes only eleven planes were lost. The attack plane version had a cannon in front and could tangle with enemy fighters, enabling the British to carry out a day-raid on Berlin in January 1943.

With their Mosquitoes the British accomplished a number of surprise raids which made the Germans uneasy. The most convincing demonstration of their high flying and tactical characteristics was the destruction of a dam in Holland.

In December 1941 the United States entered the war against Germany, and from then on most of the bombers involved in raids on Germany were the Flying Fortresses (B-17) and Liberators, four-engined planes with approximately the same bomb load as the British planes. The American planes were faster than the British planes; they were well armed for defense with machine guns and were less vulnerable. Still the Americans had to provide fighter cover in every large-scale raid of Flying Fortresses.

The Flying Fortresses raiding Germany were usually based on British airfields. The planes flew to the target in waves at specified intervals and from different directions. This created difficulties for the German air defense. Such tactics made it impossible for the Germans to concentrate their anti-aircraft defense, and they had to disperse even more their fighter forces which were already weakened because of the Eastern front.

The United States before the war had a strong transport aviation, but their combat aviation was much less developed than the Luftwaffe. As soon as the war started, the Americans built new combat planes and produced them in large numbers.

At the beginning of World War II the strength of the American aviation were bombers: the B-17 called the Flying Fortress, with a speed of 481 kph, a range of 2736 km, a bomb load of 2742 kg, and the Liberator with a speed of 483 kph, a range of 4023 km, a bomb load of 1360 kg; and the single-seater P-40 fighter with a maximum speed of 520 kph. Later in the war the Americans greatly improved their aircraft and produced large numbers of B-29 bombers, called Superfortresses, with a speed of 600 kph, a range of 5300 km and a bomb load of 4080 kg, and also P-51 fighters, Mustangs, with a speed of approximately 600 kph, and the P-38, Aircobra, with a speed of 580 kph.

At the same time the Americans produced heavy fighters, P-47 (Thunderbolt) and P-38 (Lightning), both with a speed of 640 kph. Their ceiling and range were gretaer than those of the former planes, and were mostly used for escorting bombers.

Finally the Americans designed and produced in large quantities a plane which was most popular with all the allies at that time, the military transport plane Douglas C-47, the military version of the DC-3 passenger plane. Its speed was 346 kph, its range 2400 km, and it could transport twenty-five persons.

The American aviation had its peculiarities. Unlike the Russians, British and Germans, the Americans greatly emphasized the production of bombers; fighters took second place. This decision is understandable, because the Americans did not have to fear enemy attacks by bombers. The enemy could not reach them across the ocean.

Most of the American planes were Flying Fortresses which operated against Germany and Japan. At first, from airfields in Britain and later

from southern Italy, these planes were able to bomb Berlin and other towns in Central Germany. In the Far East the Americans with their Flying Fortresses could reach Japan from their bases.

The Flying Fortress was a heavy long-range bomber. It had to have sufficient fuel in order to reach a distant target and return to base. It had great lifting power and was very heavy, weighing about 27 tons, and it needed huge power. It had four 1200 hp engines.

Each such plane could carry several tons of bombs and transport them over a distance of 3000—4000 km. When the target was nearer (1000—2000 km), the plane took on less fuel and more bombs, 5 or 6 tons. The greater the distance to the target, the more fuel and the less bomb load.

On the other hand, not all military objects on German territory were within the range of the bombers flying from bases at the Americans' disposal; the range of the bombers was not great enough. The Americans therefore organized together with the Soviet air force command the so-called shuttle operations of the American bombers. Flying Fortresses took off from air bases in North Africa or Western Europe, reached any point on enemy territory, dropped their bombs, and finally landed on Soviet airfields to refuel for the return trip.

On Soviet territory, near Poltava, there was an airfield which had been specially reserved to receive Flying Fortresses. They were serviced, fueled, loaded with bombs, and then they took off again for the return journey. After a second raid they returned to their own airfields.

A four-engined bomber is a complicated weapon. Equipped with modern instruments, this plane can fly blind for many hours and maintain radio communication over thousands of kilometers. It is equipped with radar, enabling it, when flying blind or at night with zero visibility, to reach its target accurately and to bomb through the cloud cover. The Russian heavy four-engined bomber of World War II, the Pe-8, had about the same tactical and flying characteristics.

The main task of the American fighters Thunderbolt, Mustang, and Aircobra was to escort bombers. They therefore needed a long range and a large fuel reserve, therefore lowering their combat qualities and making them heavier than the Messerschmitt, Spitfire and Russian fighters.

The Americans had a well-developed naval aviation. During the war they built many aircraft carriers. These are special vessels of which the upper deck is a runway. Under the protection of warships and fighters, aircraft carriers secretly approach the target to be bombed. Tens of aircraft, light single-engined bombers and torpedo bombers, are lifted by aircraft elevators from the holds onto the flight deck and take off. After having fulfilled their mission, they return to the carrier.

In view of the large distances in the Pacific theater of operations it was not always of advantage to the Americans to carry out raids with four-engined bombers. After all, even the Flying Fortresses could only fly so far and no more. Before the Americans captured several Pacific islands and built on them airfields for Flying Fortresses, aircraft carriers played an important role in the war against Japan.

The American air force caused the Germans heavy damage. It destroyed considerable parts of Berlin, Dresden, Frankfurt-on-Main and other cities. It is characteristic that in raids on industrial centers

the American air force avoided destroying important German enterprises; American monopolies expected to take possession of them.

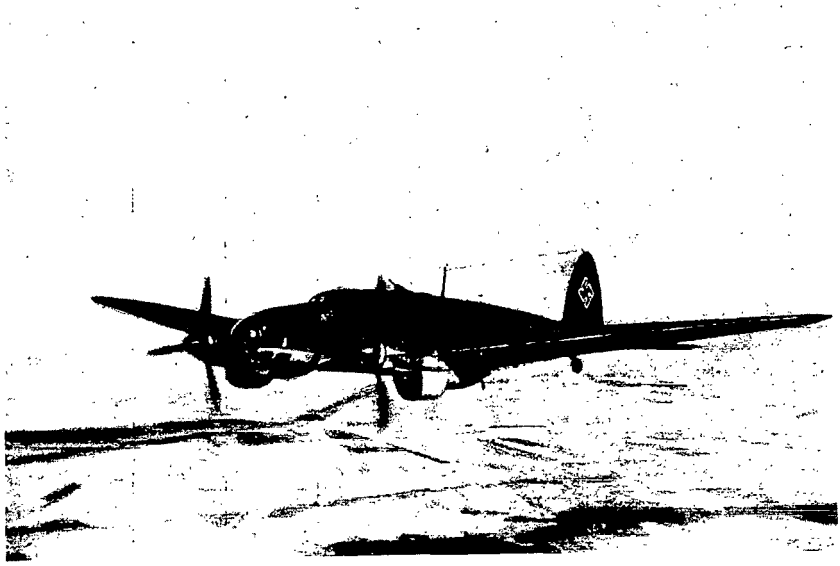
The successful offensives of the Soviet forces in summer 1944 caused the Allies to speed up opening the much-delayed second front in the West. The Allied air forces played an active part in this operation. On 6 June 1944 Anglo-American airborne troops invaded occupied France. Many planes towing gliders with troops and weapons, protected by Spitfires, Aircobras and Mustangs, crossed the English Channel. Above the coast the gliders were detached and landed on French territory. Parachutists, arms and ammunition were also dropped from four-engined transport planes. Hitler's Atlantic Wall was breached.

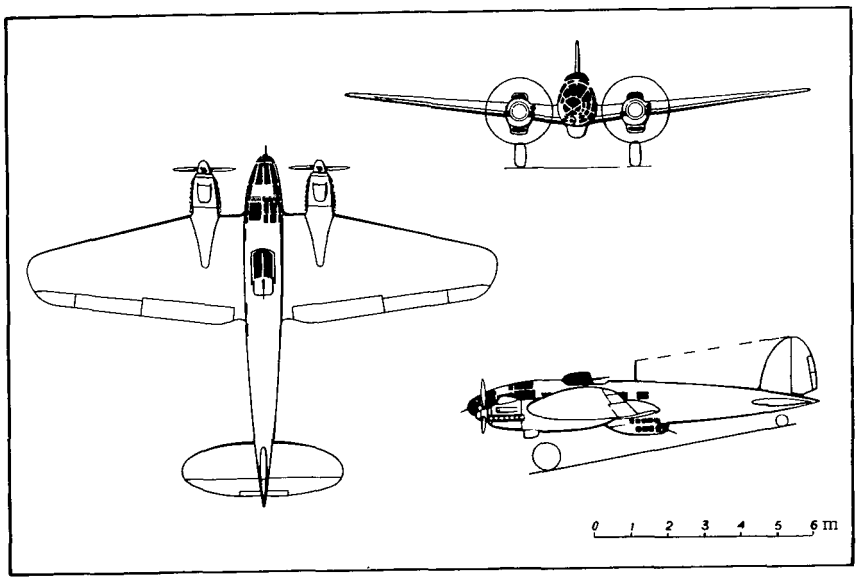
Non-Russian combat planes in World War II

Type of aircraft	Year of production	Engines (type, number, take-off power)	Take-off weight, kg	Armament and bomb load	Crew	Maximum speed, kph	Range, km	Altogether produced
Germany								
Heinkel He-111H	1935	Jumo 211, 2 x 1400 hp	14,000	3 7.92 mm machine guns; 1000 kg of bombs	4	400	2,300	5,600
Junkers Ju-87D	1935	Jumo 211, 1400 hp	6,600	4 7.92 mm machine guns; 500 kg of bombs	2	310	1,920	5,000
Junkers Ju-88A	1936	Jumo 211, 2 x 1400 hp	14,075	4 7.92 mm machine guns; 1000 kg of bombs	4	465	2,500	15,000
Messerschmitt Me-109E	1936	DB-601, 1150 hp	2,605	1 20 mm cannon; 2 7.92 mm machine guns	1	570	660	33,000
Focke-Wulf FW-190A	1939	BMW 801, 1700 hp	3,862	2 20 mm cannons; 2 7.92 mm machine guns	1	604	983	20,000
Britain and USA								
Boeing B-17G Fortress III	1935	Cyclone 9, 4x 1200 hp	26,762	12 12.7 mm machine guns; 2742 kg of bombs	9	481	2,736	12,726
Hawker Hurricane II	1935	Merlin 20, 1280 hp	3,266	12 7.69 mm machine guns	1	520	869	16,750
Supermarine Spitfire V	1936	Merlin 45, 1185 hp	3,004	8 7.69 mm machine guns*	1	585	772	22,000

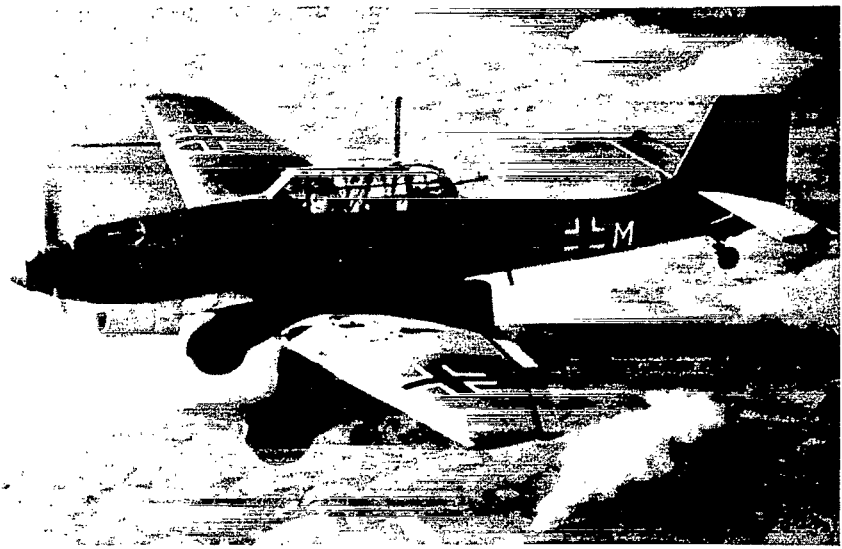
Curtiss P-40B Tomahawk	1938	Allison V-1710, 1080 hp	3,470	2 12.7 mm machine guns; 4 7.62 mm machine guns	1	533	1,070	14,000
Bell P-39D Aircobra	1939	Allison V-1710, 1150 hp	3,470	1 37 mm cannon; 4 12.7 mm machine guns	1	579	926	9,584
Lockheed P-38E Lightning	1939	Allison V-1710, 2x 1150 hp	6,958	1 20 mm cannon; 4 12.7 mm machine guns	1	635	1,408	9,923
Avro 683 Lancaster I	1939	Merlin 20, 4x1280 hp	27,215	8 7.69 mm machine guns; 1927 kg of bombs	7	440	4,040	7,374
North American P-51 Mustang	1940	Allison V-1710, 1150 hp	3,810	4 12.7 mm machine guns	1	615	1,609	15,000
De Havilland DH-98 Mosquito IV	1940	Merlin 21, 2 x 1280 hp	9,130	No armament; 454 kg of bombs	2	611	1,940	7,781
Consolidated B-24 Liberator	1940	Twin Wasp, 4x1200 hp	28,123	10 12.7 mm machine guns; 1360 kg of bombs	10	483	4,023	19,000
Boeing B-29 Superfortress	1942	Cyclone 18, 4x2200 hp	54,430	1 20 mm cannon; 10 12.7 mm machine guns; 4080 kg of bombs	10	598	5,300	4,547

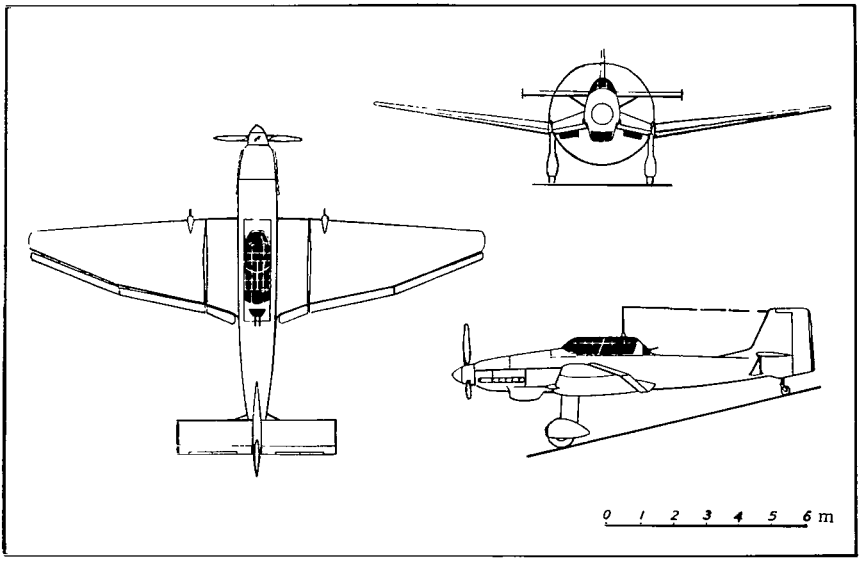
* There were also versions with wing-mounted cannons.



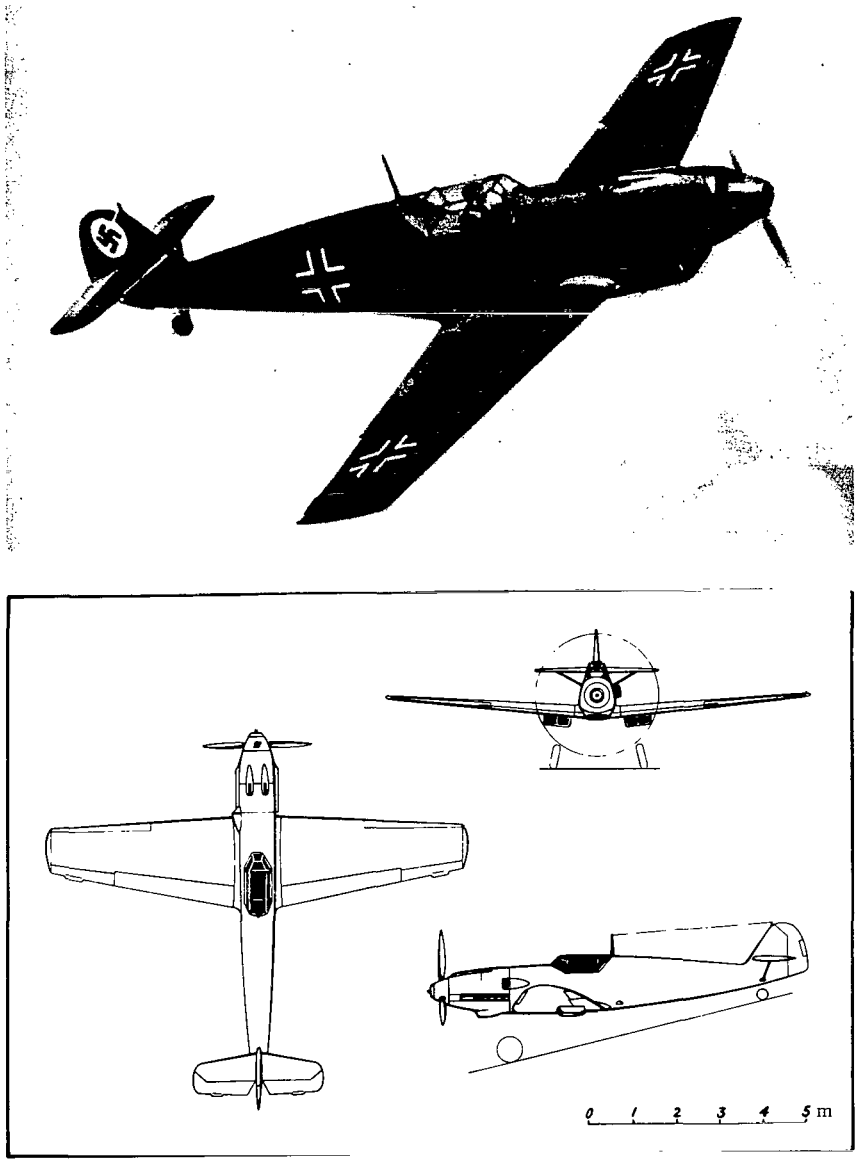


Bomber Heinkel He-111, 1935.

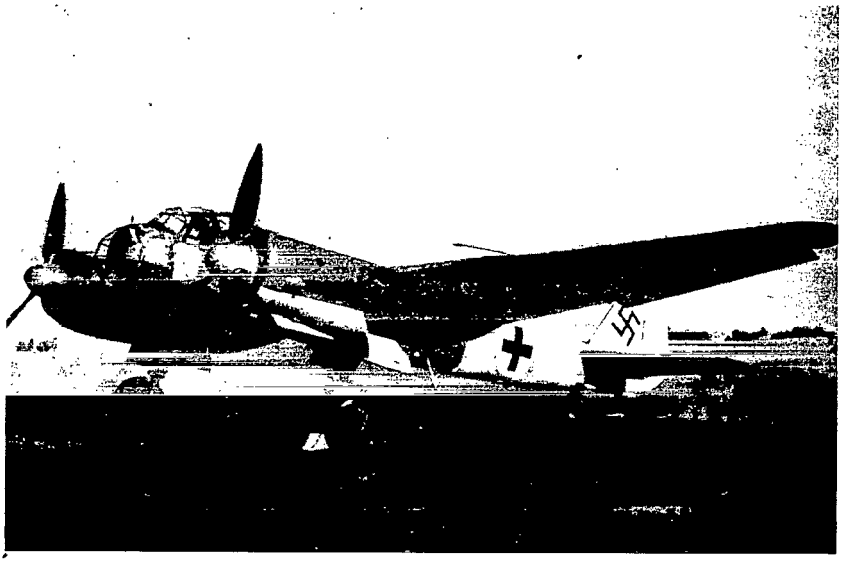


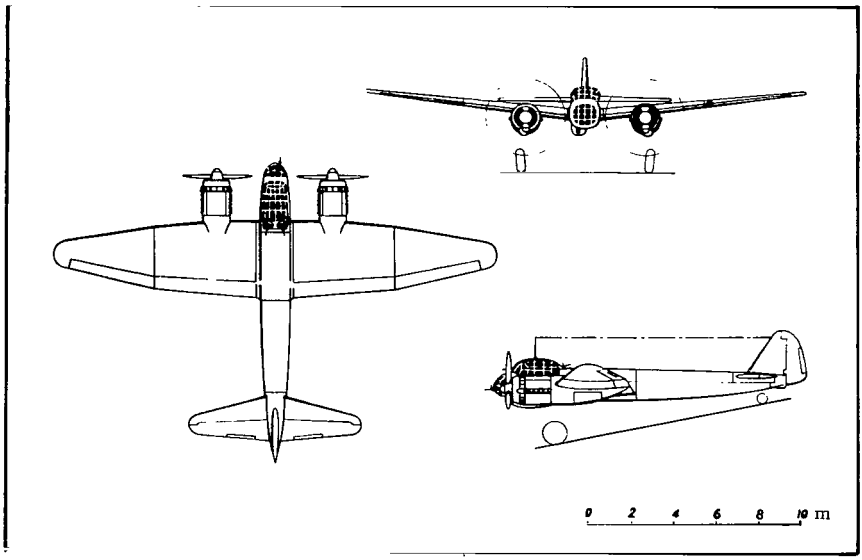


Dive-bomber Junkers Ju-87, 1935.

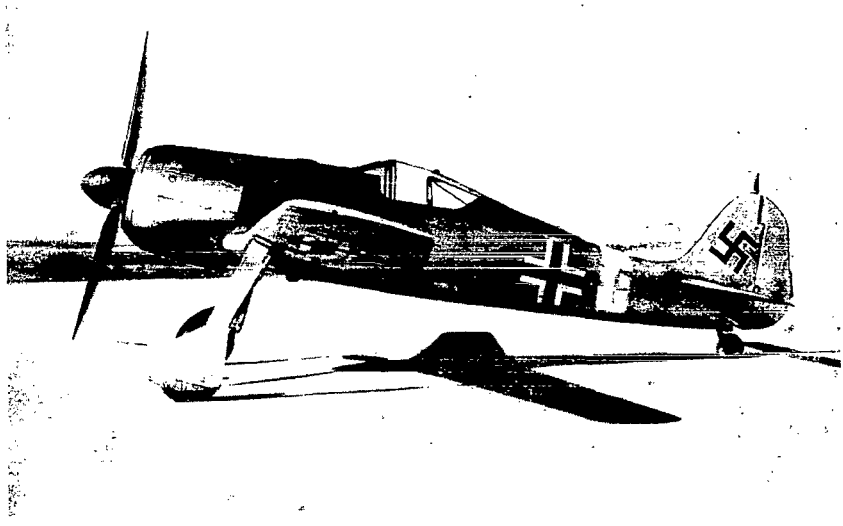


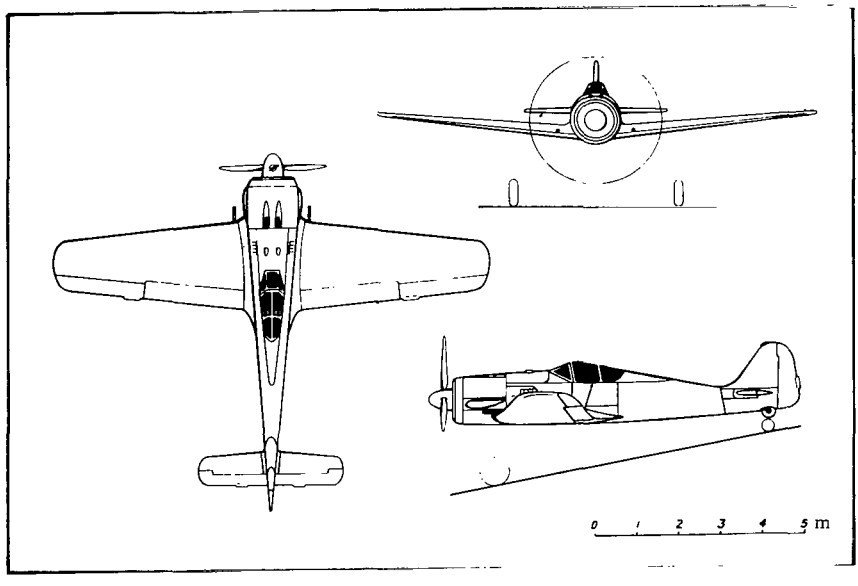
Fighter Messerschmitt Me-109, 1936.



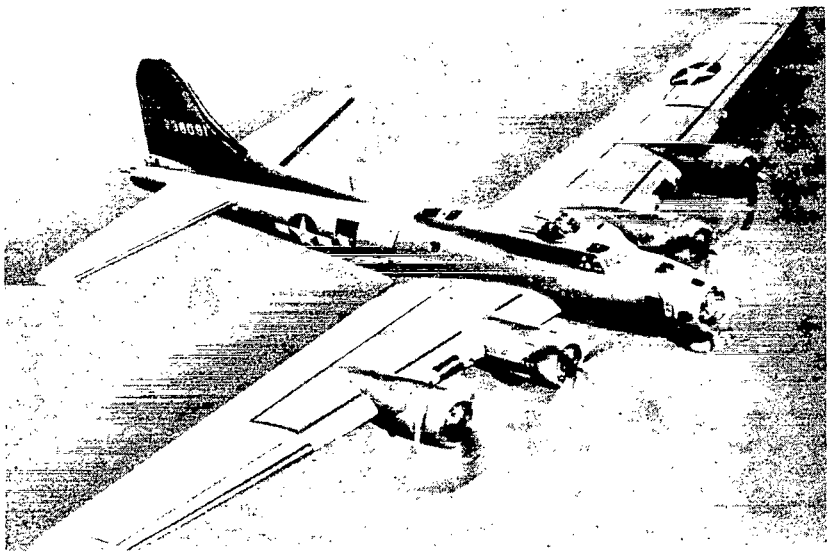


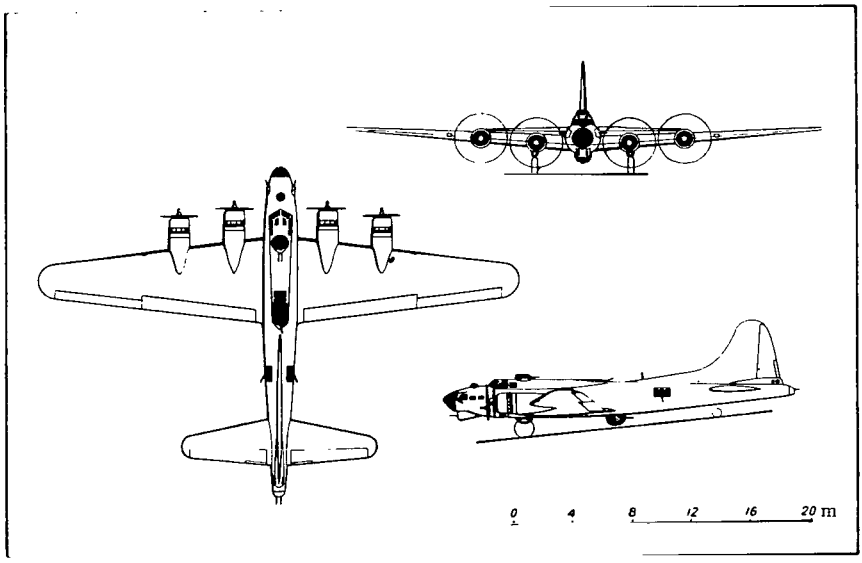
Dive-bomber Junkers Ju-88, 1936.



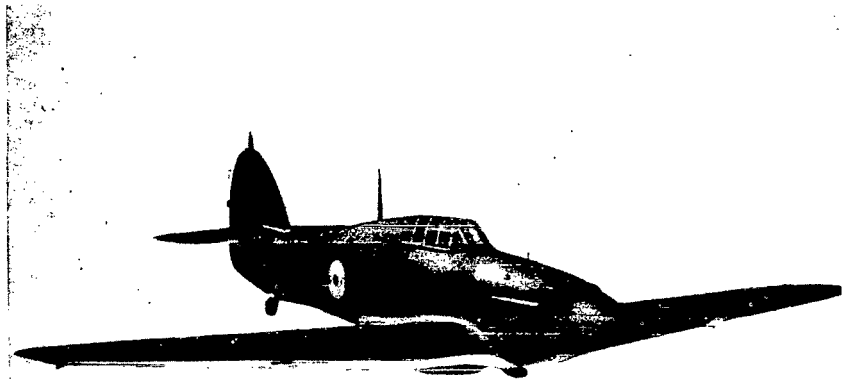


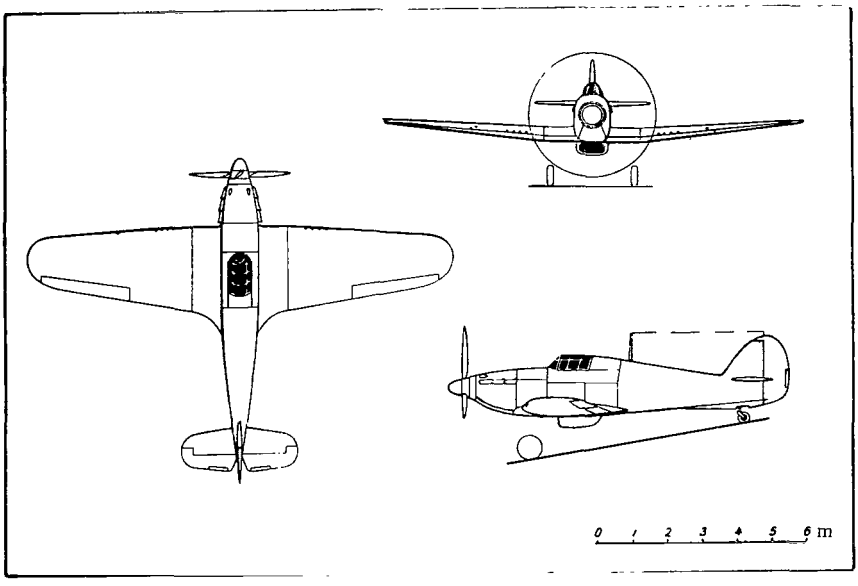
Fighter Focke-Wulf FW-190, 1939.



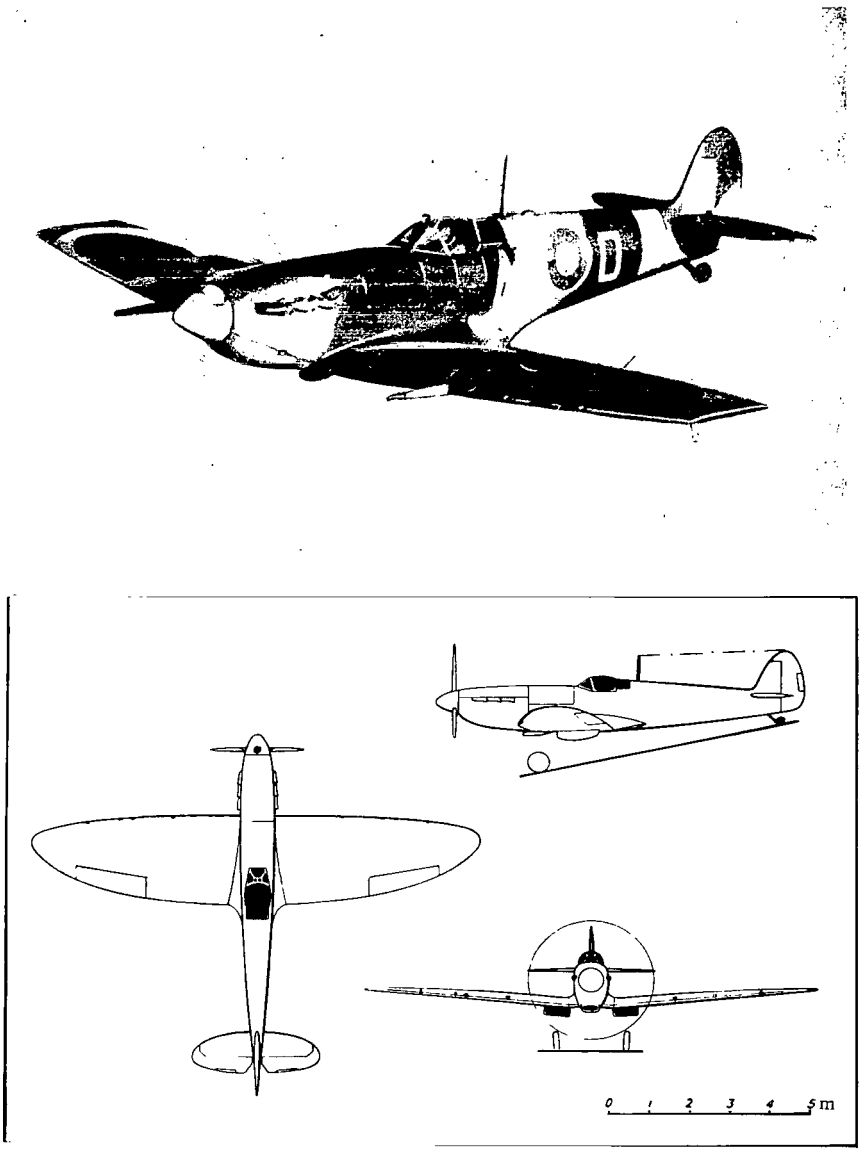


Long-range bomber Boeing B-17 Fortress, 1935.

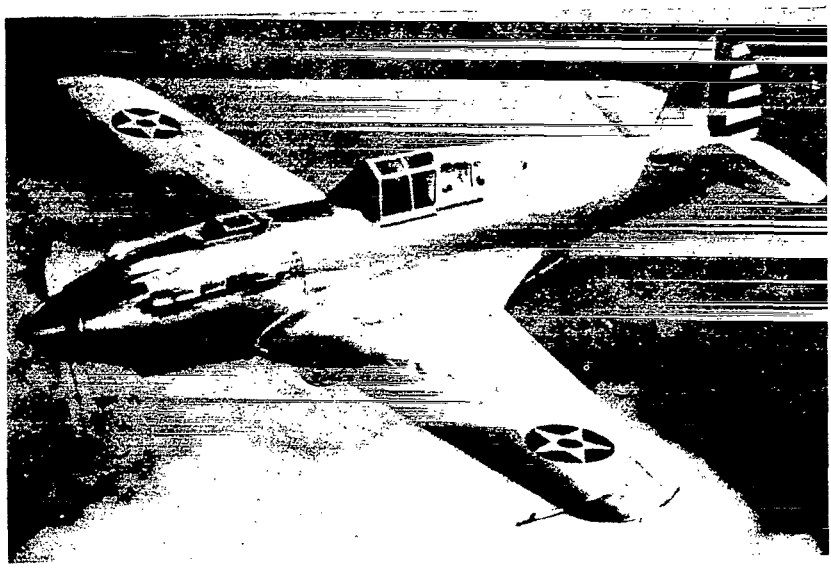


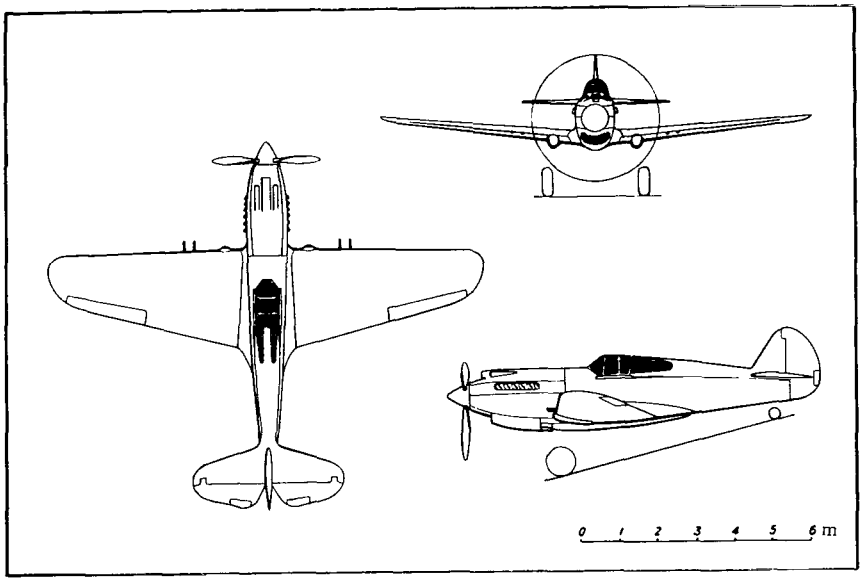


Fighter Hawker Hurricane, 1935.

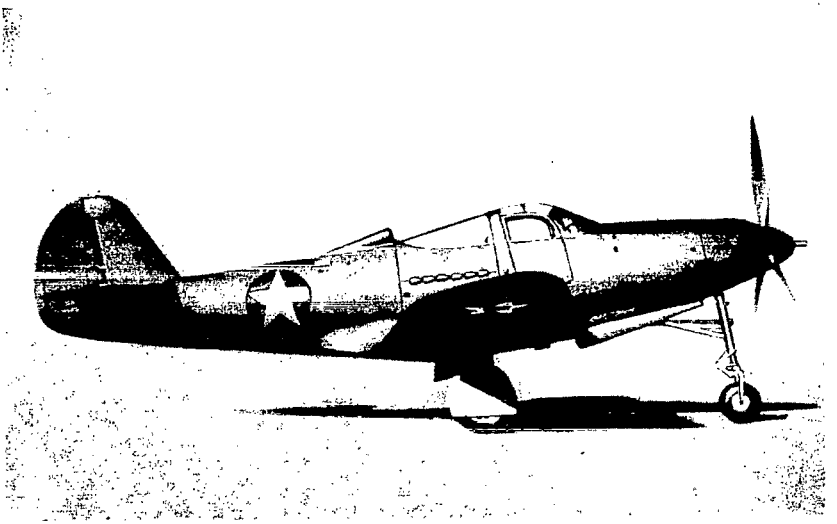


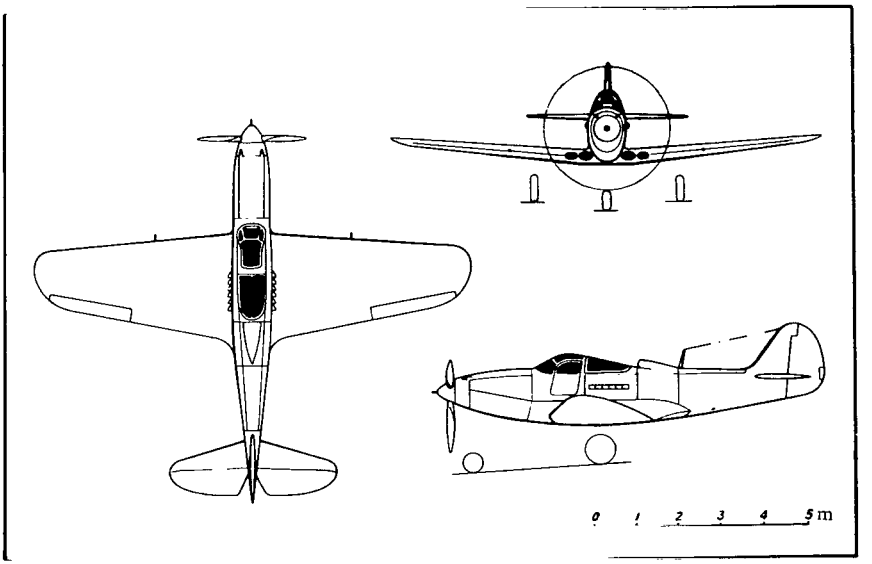
Fighter Supermarine Spitfire, 1936.



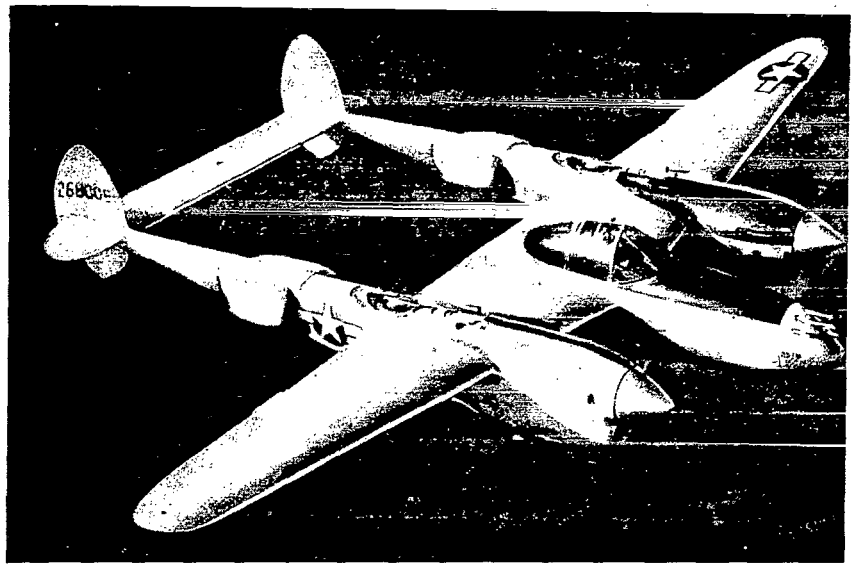


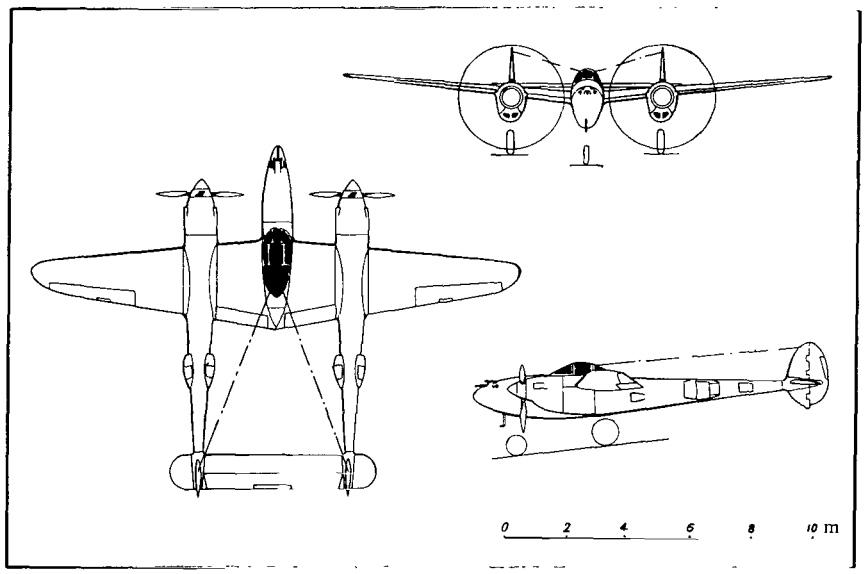
Fighter Curtiss P-40B Tomahawk, 1938.



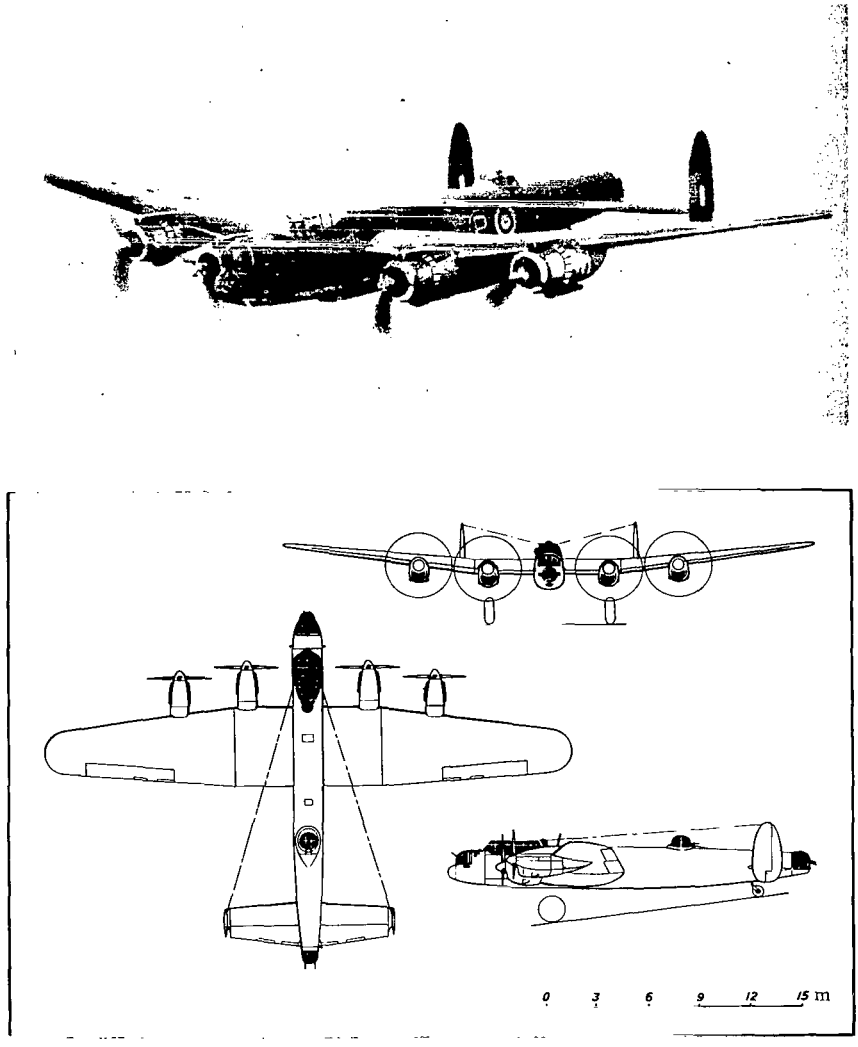


Fighter Bell P-39 Aircobra, 1939.

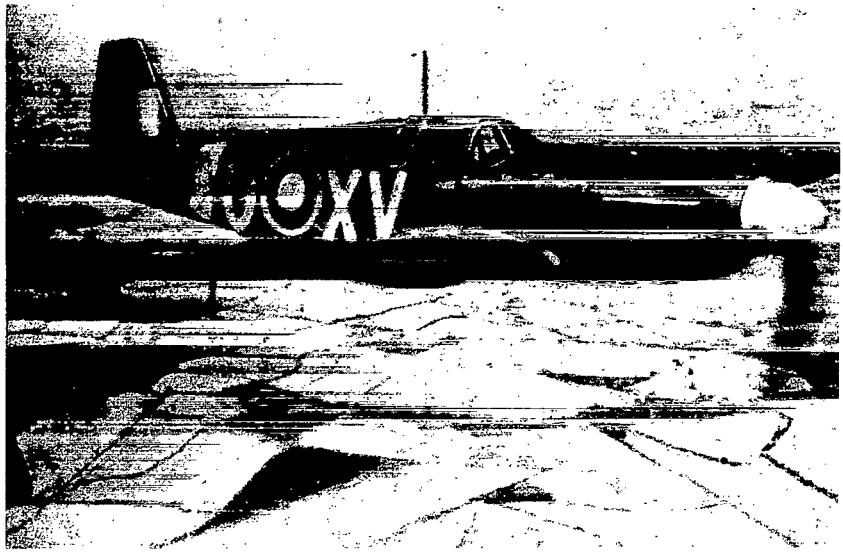


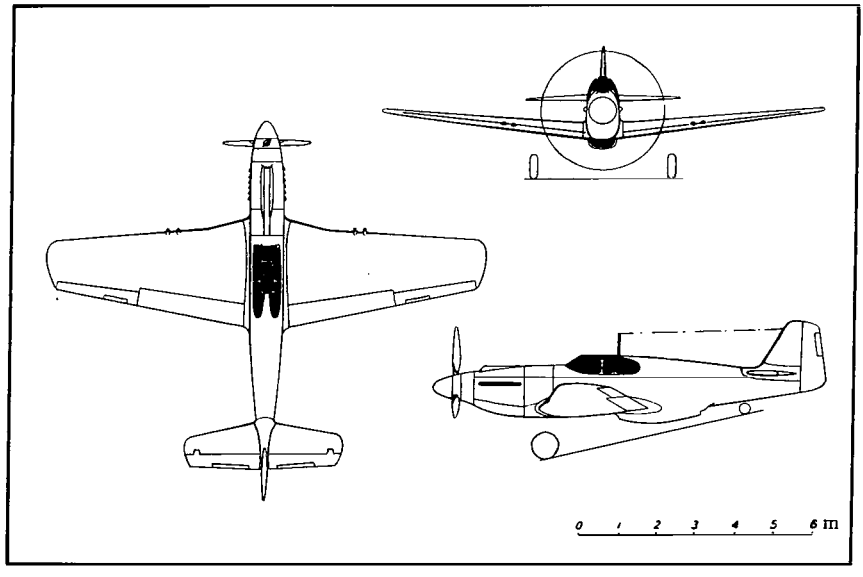


Escort fighter Lockheed P-38 Lightning, 1939.

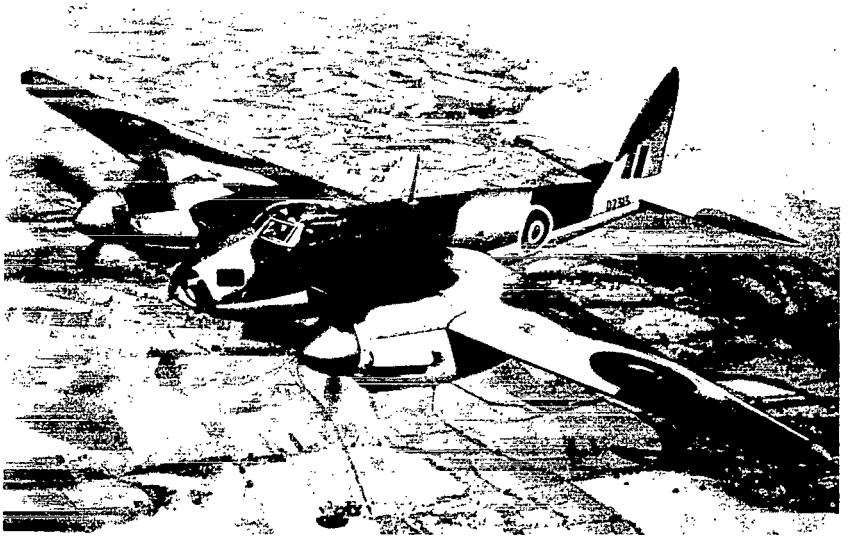


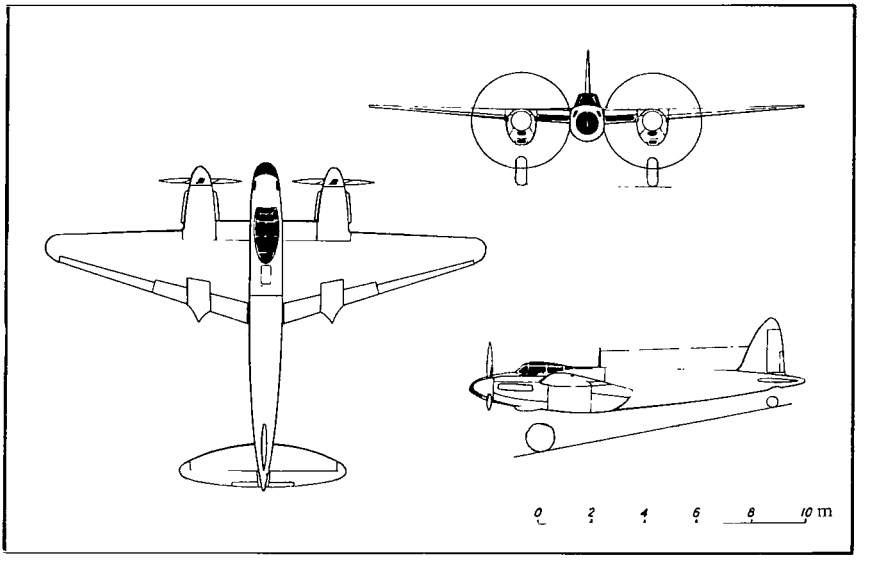
Long-range bomber Avro 683 Lancaster, 1939.



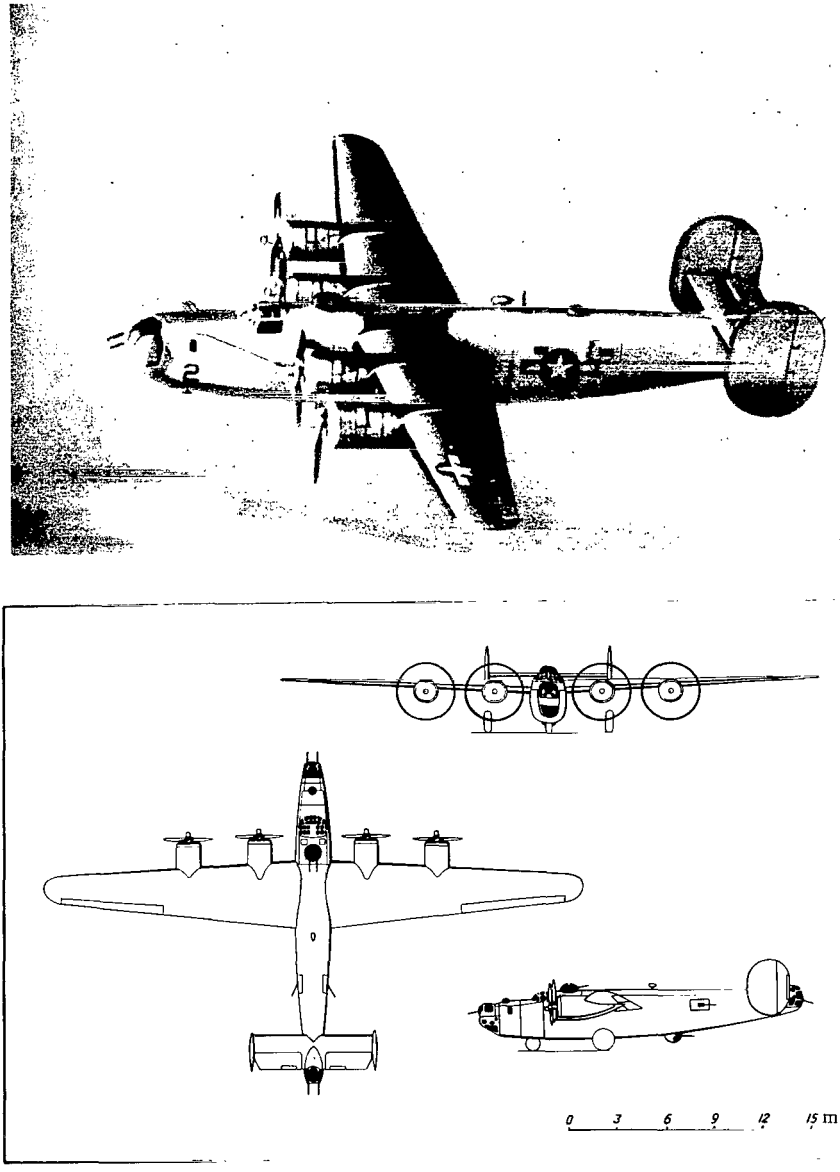


Fighter North American P-51 Mustang, 1940.

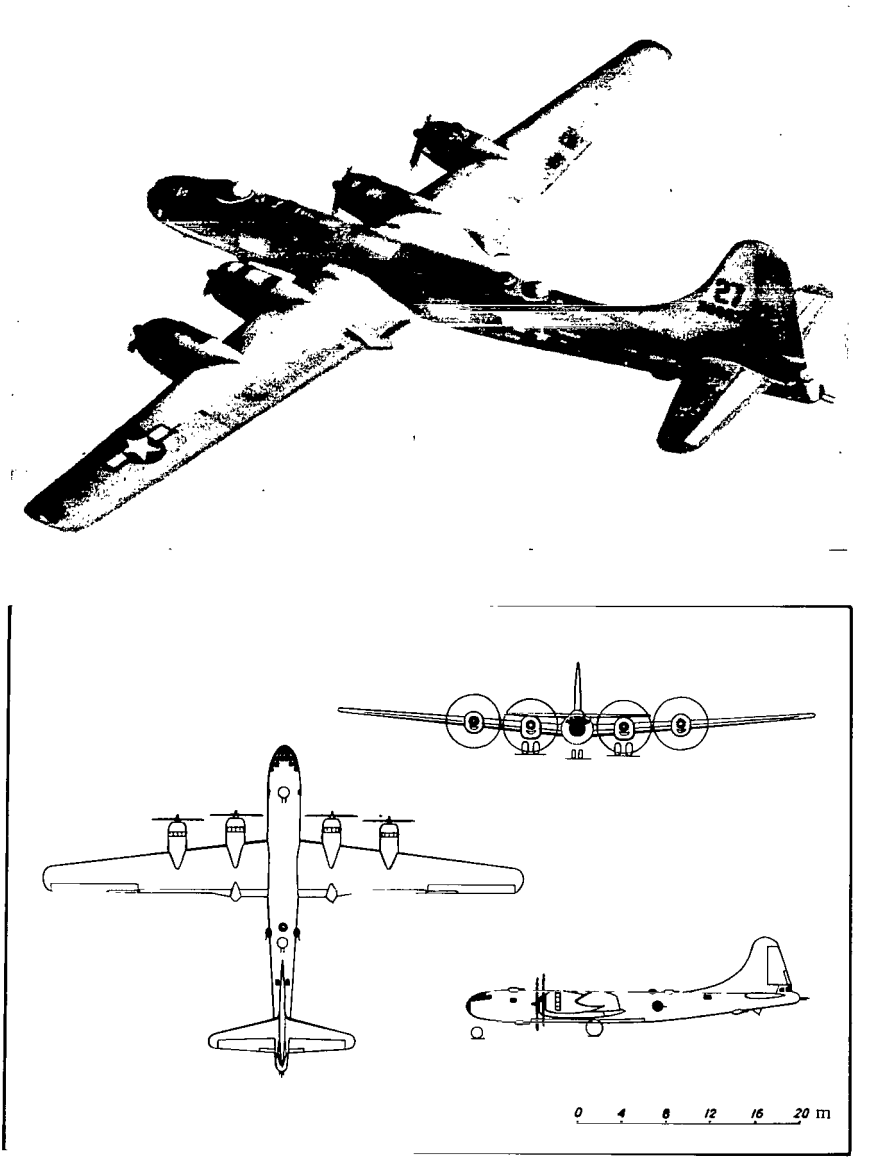




Bomber De Havilland DH-98 Mosquito, 1940.



Long-range bomber Consolidated B-24 Liberator, 1940.



Long-range bomber Boeing B-29 Superfortress, 1942.

6. *THE VICTORY OF SOVIET TECHNICAL GENIUS*

The war gave its verdict on different aviation doctrines and objectively assessed the level and trend of aviation in the largest countries of the world.

Experience gained in the war confirmed the correctness of the Soviet military doctrine of harmonious cooperation among all types of forces. Both the fascist theory of "blitzkrieg" and the Allies' total bombing of Germany proved unsuitable.

The policy of Soviet aircraft designers was fully vindicated. They strove for maximum simplicity and economy in design, especially in wartime.

Improvements on planes and engines were carried out without interfering with their mass production and without prejudice to the supply of combat aircraft to the front.

In the fierce air battles of World War II Germany lost two-thirds of its aircraft at the Eastern front.

The victory of the Soviet people in World War II was the historical result of the development of the country's armed forces, including the air force. Only if we have this result in mind, can we understand how the Soviet army achieved air supremacy and dealt the Luftwaffe a crushing defeat and can we comprehend the correctness of the new approach chosen by Soviet aviation after the war. Wartime experience will for a long time to come be a subject for research, both by military historians and strategists and by scientists, designers, and all others involved in the creation of the armed might of the Soviet state.

If we analyze the results of the war, we may first of all speak of the collapse of the German idea of "blitzkrieg" and the failure of "Douhet's doctrine."

Raids on London and other British cities by pilotless flying bombs did not enable the Nazis to attain their goal, to force the British into submission.

During the war the English organized their air-raid defense in an exemplary manner. Spitfire fighters and anti-aircraft artillery caused Goering's aerial pirates heavy losses. Each raid cost the Germans more and more losses, losses in bombers and airmen, considered irreplaceable. In the end they had to forgo air raids and admit their defeat in the air war against Britain.

The Allies also did not attain any decisive successes by only bombing. As late as July [sic] 1944, when they were afraid of the rapid advance of Soviet forces in the East, the Americans and British landed on the north coast of France and opened the so-called second front. Until then the Allies had limited their combat actions in Europe mainly to air raids. However, in spite of the fierce bombing, the Germans firmly stood their ground.

The war proved how inefficient was the Anglo-American effort to subdue Nazi Germany only by a fleet of heavy bombers. The Observer wrote in 1961 that according to data on the effect of bomber forces published in

"Attack of Strategic Aviation against Germany 1939—45" by Charles Webster and Nobel Frankland, losses of the German war industry as a result of British bombing constituted only 3.2 percent in early 1943, 6.9 percent in late 1943 and 2.4 percent in early 1944. In 1944 the Allied strategic bomber force dropped about one million tons of bombs on German territory but did not succeed in seriously impairing Germany's military and economic potential.

An example of the futility of this policy are the results of air raids with incendiary bombs on Lübeck and Rostock in 1942. Although Lübeck was "successfully burnt," we now know that a week later production there reached 90 percent of its normal level.

One of the main objects of massed Anglo-American air raids was the destruction of aircraft plants, especially those making fighter aircraft. Output of these planes, however, increased incessantly. Output of fighters Me-109 was: 449 in 1939, 1693 in 1940, 2764 in 1941, 2665 in 1942, 6247 in 1943, and 13,786 in 1944.

The fight for Stalingrad is also convincing evidence that the air force alone cannot decide a battle. On some days the Germans flew two thousand sorties but were unable to break the Soviet defense.

No matter how great the role of heavy bombers is in modern warfare, Nazi Germany could be defeated only by the simultaneous efforts and cooperation of all types of weapons. This is the essence of the Soviet military doctrine.

The advantage of the Soviet aviation during the war lay in the close cooperation with all kinds of weapons of the Soviet armed forces. The backbone of the Soviet army air force was tactical combat aircraft. Therefore there was practically no room for heavy bombers similar to the American Fortresses or the British Lancasters, or for escort fighters, such as the Thunderbolts and Lightnings.

An analysis of the development of combat performance of aircraft in World War II shows that the requirements of the armies for combat aircraft were limited to four or five basic types simultaneously produced. This proved to be correct both for the Soviet aviation and for the German Luftwaffe.

The main mass-produced German combat aircraft in the war 1941—45 were:

Fighters with water-cooled engine	Me-109
Fighters with air-cooled engine	FW-190
Dive-bomber	Ju-88
Attack plane	Ju-87

The main types of aircraft in the Soviet air fleet during the war were:

Fighters with water-cooled engine	Yak
Fighters with air-cooled engine	La
Twin-engined dive-bomber and reconnaissance aircraft	Pe-2
Attack plane	Il-2
Long-range twin-engined bomber	Il-4

Main type I means mass-produced aircraft of which tens of thousands were made and which decided the aerial battles in the East, fateful to the Germans. For instance, up to the end of the war the following were

produced: attack planes Il — 39,000; fighters Yak — 36,000, La — 22,000, MiG — 3400; bombers Pe-2 — 11,000, Il-4 — 6500, Tu-2 — 800.

Regarding heavy long-range bombers, their role in war is great, as shown by the enormous damage inflicted by the Allies on German cities. As mentioned before, however, the British and Americans, who used these aircraft on a large scale, were unable to achieve decisive military success.

It was partly this reason which brought about the decision at the climax of the war to discontinue production of Pe-8 heavy bombers. In total only seventy-nine such aircraft had been produced, and production was stopped in favor of the light bomber Pe-2. The economy and the production facilities of the Soviet Union at that time did not permit simultaneous production of both types of aircraft. After all, the war required many other aircraft types, e.g., troop transport planes, liaison, trainer aircraft. These aircraft were of auxiliary character and did not directly affect the aerial might of the army.

War experience confirmed that Soviet technical thinking about aircraft was accurate. The main Soviet aircraft — fighters Yak and La, attack planes Il, and bombers Pe — were all through the war superior in combat qualities to the corresponding German types Me-109, FW-190, Ju-87 and Ju-88.

Reasons for this superiority were that Soviet aviation had better aerodynamics, better weight characteristics, more powerful firearms (automatic cannons of 20 mm, 37 mm and 45 mm caliber), RS aircraft rockets, and a completely new and original type of armored aircraft, the Il-2 attack plane.

In addition, the Soviet Union succeeded in improving the combat qualities of aircraft without increasing their weight. The series-produced Yak-3 fighter weighed 2650 kg, and with the same engine its speed, maneuverability and armament were much better than those of the original version, the Yak-1, weighing 2895 kg.

The Soviet planes built in 1939—40 had great potential for improvement, whereas by the time the war started the German planes, having been built in 1935—36, had been exhausted of any such possibility.

Because the modernization of Yak and La fighters and of Il and Pe attack planes and bombers was technologically well prepared, it was usually accomplished without loss of output. Under wartime conditions, even when a new type of aircraft is prepared, the peculiarities of series-production technology have to be considered to avoid loss of time.

The German Major-General von Butlar in his analysis of the war noted: "... the Russians had the advantage that in the production of arms and ammunition they took into account all the peculiarities of warfare in Russia and ensured maximum simplicity of technology. As a result the Russian plants produced enormous quantities of armaments which excelled by the simplicity of their design. It was comparatively easy to learn to handle such arms ..."* This admission of a former enemy is convincing enough.

World War II fully confirmed the mature, independent and far-sighted scientific and technical thinking in the USSR. These qualities also underlay the rapid advance of the Soviet air force in the postwar period, at the dawn of the jet era.

* Mirovaya voina 1939—45 (The World War 1939—1945), p. 217.

In their postwar memoirs and works dealing with the history of World War II the former German generals like to discuss the causes of their defeat in the war against the Soviet Union. Such military figures as the famous commander and founder of the German armored forces Colonel-General Heinz Guderian, General Kurt von Tippelskirch and others question whether Germany could have defeated the Soviet Union if it had not been for a "coincidence of unfavorable circumstances." What "unfavorable circumstances" were these?

One of the causes Western memoir writers want to attribute to Germany's defeat is the aid that the United States extended to the Soviet Union during the war. This circumstance, compounded with Hitler's mistakes and the myth of the powerful Russian ally, "General Winter," are favorite arguments of Western military and political authors. They would like to detract from the role of the Soviet army, Soviet industry, and the valor of the Soviet soldiers as factors in attaining victory over Nazi Germany.

In reality all the American aid to the Soviet Union, all the deliveries under the Lend-Lease Bill throughout the war did not amount to more than 4 or 5 percent of the total output of aircraft, tanks, weapons and other munitions in the United States between 1941 and 1945.

During the war years the United Stated produced altogether 297,000 planes, of which the Soviet Union received only about 14,000. The Americans produced more than 86,000 tanks but sent only 7000 to the Soviet Union.

At the same time the Soviet Union during the war produced annually on an average more than 30,000 tanks, self-propelled guns and armored cars, up to 40,000 aircraft, and 120,000 guns. The Soviet Union fought with its own strength.

Concerning aviation, no serious, conscientious military specialist could ascribe the Soviet victory in the air to the American assistance.

In 1941 the Soviet aircraft industry produced 15,735 planes. In the difficult year 1942, with the evacuation of aircraft plants, more than 25,000 planes were produced, in 1943 — 35,000, and 1944 — 40,300 and in early 1945 — 20,900 planes. Can the 14,000 American planes that were sent compare in any way with this great Soviet air fleet?

In the course of this greatest of wars the Soviet aircraft industry managed to outstrip considerably the German aircraft industry although Germany had at its disposal, in addition to its own resources, the resources of its allies and of the occupied countries.

In 1944 German plants produced 27,600 fighters, attack planes and day bombers, and during that same time Soviet plants supplied the front with 33,200 such planes.

The successes of the Soviet rear made it possible to strengthen considerably the air force. In 1944 aircraft production in the USSR was 3.8 times greater than before the war.

Foreign military historians and writers in many books and memoirs write in detail and at length about the exploits of the aviation during World War II on the Western front.

Neither the Soviet Union's former enemies nor allies like writing about the grandiose aerial battles in the East where two-thirds of Germany's planes were destroyed. As for the former commanders of Hitler's Luftwaffe, this much is clear: such reminiscences cannot be agreeable. When Americans and British keep quiet about the role of the Soviet air

force in defeating the Luftwaffe, hardly mention Soviet aircraft, and if they do, call them primitive, knocked together with an axe, this is simply unscrupulous.

After all, Soviet combat aircraft were much simpler in design and technology than American or German machines, but such simplicity was their advantage.

The Soviet aircraft was adapted to the difficult conditions of the initial phase of the war, the period of evacuation, a bad shortage of aluminum, instruments, various materials indispensable for mass production of aircraft, engines, and equipment. It was easy to introduce them into production by unskilled workers, mostly women and youngsters.

Nevertheless, the Russian aircraft stood up well under the brutal conditions of aerial combat on the Soviet-German front against the air fleet of Nazi Germany.

Qualitative superiority and the constantly increasing number of newly produced planes ensured Soviet aviation air supremacy as early as the beginning of 1943. Nazi Germany lost two-thirds of its planes on the Soviet-German front of World War II.

7. *JET AIRCRAFT*

When the war was over, much work was done in the USSR toward creating a large jet-powered air fleet with which to equip the air force.

As early as the beginning of the fifties aircraft with original Soviet jet engines were put into serial production.

Further development of jet aircraft was convincing proof of the high level of scientific and design expertise. At the aerial parades in 1961 in Tushino and in 1967 in Domodedovo, models of supersonic combat aircraft were shown, including the latest in aviation: a vertical take-off jet fighter (VTOL) and a supersonic multi-purpose aircraft with changeable wing shape.

The postwar period of development of Soviet aircraft production was marked by a scientific and technical revolution — the beginning era of jet aircraft. The creation of a powerful jet aircraft fleet and complete change-over to military jets and the civil air fleet was a new test for Soviet aviators and the aircraft industry. They passed this test with honor.

In the thirties it became clear that ordinary planes with piston engines and propellers had been developed almost completely, and that there was not much room for further improvement. New vistas were opened up which had been predicted by K. E. Tsiolkovskii.

During the late thirties strenuous efforts were made by research institutes and designers in the USSR, Britain, Germany, Italy, and somewhat later in the United States, to produce reactive engines. In 1938—39 German BMW and Junkers jet engines appeared, in Britain the engine designed by Frank Whittle, and in Italy the Campini-Caproni. All these were inadequate experimental jet engines but could be mounted in specially built aircraft.

The Italian designers Campini and Caproni built the CC-1 and CC-2 jet airplanes. These aircraft were flown several times in 1940 and 1941, and on 1 December 1941 a flight from Milan to Rome was carried out. In the Campini-Caproni aircraft a compressor was driven by a conventional piston engine. This power system was called motor-driven compressor. It did not ensure high flying speeds and was later abandoned. The fuselage of the Campini-Caproni plane from the nose to the tail was a tube. Air entered the round air intake in the nose, then passed into a two-stage compressor and was ejected through a jet in the rear of the fuselage at increased speed and temperature.

Before the war W. Messerschmitt began designing his jet fighter Me-262. It made its first flight in 1942. In 1942 and 1943 it was tested and was then put into serial production.

In addition to the Me-262 Messerschmitt worked on a flying wing with a liquid-propellant rocket engine, the Me-163. A small number of Me-163s and Me-262s even reached the front. These new weapons, however, did not

have any effect on the course of the war in the air. The same applies to Heinkel's jet plane, the He-162.

When the Germans put their first jet planes into operation, many of them crashed. These disasters were not caused so much by the novelty of flying jet aircraft but by that feverish haste with which the Nazis endeavored to put insufficiently tested and hastily designed planes into serial production, and then immediately to use them at the front. Under such conditions crashes could not be avoided, and this caused pilots to distrust jet planes.

In Britain Whittle's jet engine underwent tests in April 1937. After the initial defects had been corrected and the design of the engine improved, it was mounted on a plane specially built by Gloster Aircraft.

With Sayers at the controls, the jet-powered Gloster made its first flight in May 1941. In October 1941 Whittle's engine, blueprints and a group of engineers from the firm Power Jets were sent to the United States to give technical assistance to the American firm General Electric. Within a year a plane was built there, the Bell Aircomet powered by two General Electric Whittle-type engines; this was the first American jet plane.

Making use of the experience accumulated in designing, building and testing their first plane, Gloster Aircraft built the twin-engined fighter Meteor. The Meteor was the only jet plane used by the Allies in World War II. Its first flight was in March 1943. Meteors operated from bases in South England against the German rockets. On 7 November 1945 a special racing plane, the Gloster Meteor IV, established a speed world record with 969.6 kph.

In 1945 De Havilland began work on the design of a jet-powered flying wing, the DH-108. Two prototypes were built. In April 1948 with one of them the test pilot John Derry broke the world speed record on a closed 100-km circuit; his speed was 973.81 kph. In September he attained a speed of 1120 kph, i.e., almost the speed of sound, in diving from an altitude of 12 km to 9 km.

However, the British were not successful with their DH-108. Soon both planes crashed after having broken up in the air, burying the courageous pilots under their wreckage.

The crashes of the DH-108s, whose flights until then had been excessively publicized as a national triumph, and the loss of the test pilots had a depressing effect. This was enhanced by the unconvincing reasons given for the crashes, published by the press and surrounded by many mysteries. It was speculated that when a plane approaches a speed of 1000 kph, the air becomes so compact (this was at the time called the sound barrier) that upon contact with it the wings and other parts of the aircraft cannot absorb the impact, and thus are damaged. Such tales undermined the confidence of pilots in jet planes. The real cause was that designers did not yet have enough experience to analyze stress of such fast aircraft correctly.

Distrust in jet craft also spread in the Soviet Union, because there too the first flights of jet-powered aircraft had a tragic ending.

In the USSR in the initial period practical work in the construction of reaction engines was done by many inventors and designers who mostly concentrated on liquid-propellant rocket engines.

This work was greatly influenced by the work of Tsiolkovskii's successor, the scientist and designer F. A. Tsander, who built the first reaction engines in 1930—33. Unfortunately these were not put to practical use at that time.

In the late thirties two designers, A. M. Isaev and L. S. Dushkin, produced liquid-propellant reaction engines mounted later in specially built aircraft.

The first flight powered by a reaction engine in the USSR was in February 1940 by pilot I. Fedorov on an SK-9 rocket plane, the work of Sergei Pavlovich Korolev, the famous builder of spacecraft.

In February 1942 the test pilot Captain Grigorii Bakhchivandzhi was preparing at an aerodrome for flight tests of a plane designed by V. F. Bolkhovitinov and powered by a liquid-fuel reaction engine designed by Isaev and Dushkin. The plane was built under difficult wartime conditions, the flight tests were made in extremely cold weather, in isolation from the scientific base. Nevertheless, as early as 15 May 1942 Bakhchivandzhi made his first successful flight. Soon after, on a subsequent flight, the pilot accelerated to full thrust, the plane lost its stability, became uncontrollable and crashed.

Further development of reaction propulsion then changed from liquid-propellant reaction engines to turbojet engines. A pioneer of turbojet engines was A. M. Lyul'ka, a turbine designer who in 1937 began working on his first turbojet engine.

It is fitting here to point out that toward the end of the war the speed of fighter planes approached 700 kph. Developing a proven configuration, S. A. Lavochkin designed the La-9, a fighter armed with four cannons with a speed of 690 kph. The Yak-3 with a VK-107 engine attained 720 kph in government tests.

When aircraft attain what was then considered high speeds, the air becomes compressible, the resistance of the aircraft increases sharply and the efficiency of the propeller drops. It was therefore practically impossible to increase speed by improving streamlining, and to increase the power of piston engines would have caused the weight and size of the power plant to increase disproportionately. This circumstance was a serious obstacle to further increase in aircraft speeds.

A measure which could be quickly effected but was only a stopgap was to fit fighters powered by piston engines with so-called boosters, i.e., auxiliary liquid-propellant reaction engines or ramjet engines for short bursts of higher speed. The first models of this kind were the Yak-3 with a liquid-propellant reaction engine and experimental MiGs and La-5s with ramjet engine boosters.

A fundamental solution would be production of engines operated on a new principle, turbojet engines, which have great advantages over piston engines, because they can develop enormous thrust, yet their weight and size are comparatively modest. In addition, the engine transmits its energy directly to the aircraft, without the intermediary of the heavy and cumbersome propeller. After the war the Soviet designers were able to concentrate on problems of reaction propulsion.

The Central Committee of the Party and the government in December 1945 discussed several times the future development of Soviet aviation. To keep in the forefront of progress, especially in the field of reaction propulsion, it was decided to adopt urgent measures to improve the construction of prototypes of new types of aircraft, engines, and equipment, and to extend the greatest possible assistance to research.

At the end of December 1945 an unsuccessful attempt was made to avoid having to carry out these radical measures by simply copying the German

Me-262. This problem was discussed on a recommendation by the People's Commissariat of the Aviation Industry. The recommendation was rejected. To put the Me-262 into serial production would be a mistake. First, this was not a successful plane; it was difficult to control and unstable in flight. Second, copying the Messerschmitt would direct attention and material resources to this plane, greatly damaging progress of Soviet jet aircraft.

Moreover, at that time the work of Soviet designers of jet aircraft was progressing successfully. Mikoyan's design office worked on the twin-engined fighter MiG-9. Yakovlev's design office brought out the single-engined fighter Yak-15 in October 1945; it was already on the airfield for preliminary tests and for taxiing. The MiG-9 and Yak-15 promised to be lighter, easier to fly, to have better flying characteristics and be more reliable than the German planes. They could be put into serial production more easily.

In his postwar memoirs the German General Kurt von Tippelskirch wrote about the Me-262: "... The necessity of introducing changes in design in the end had the result that when the Allies invaded France, there were altogether only thirty such planes which had been already delivered to the air force units, but changes had yet to be carried out on them." He also complained that the pilots "did not learn properly to handle the new machine, especially in take-off and landing."*

While rejecting the proposed copying of the Me-262, the government decided to speed up production of the Yak-15 and MiG-9, so that they could be shown at the Tushino air display in 1946.

The problem of developing jet aircraft in the USSR was solved by the decision to use an original approach.

Measures for greatly intensifying experimental and research work in construction were outlined. One of the outstanding politicians and organizers of the defense industry, M. V. Krunichev, was in December 1945 made minister of the aviation industry. The staffs of the design offices went to work with great vigor, realizing clearly how complicated and demanding was the changeover from piston-engines to jet propulsion. The government provided the necessary conditions.

The designers working on the Yaks set themselves the task of producing an aircraft in which only the engine would be new while the rest would as much as possible remain the same as in piston-engined aircraft. Upon entering the cockpit, the pilot would take up his accustomed position, and in taking off, landing, and in flight he would not feel any difference between the jet and a piston-engined plane.

This concept was realized. The Yak-3 fighter, with which the pilots were familiar, was fitted with an RD-10 turbojet engine. Fundamental changes had to be made only in the front of the plane, with the cockpit, wings, empennage and landing gear remaining substantially unchanged. It was calculated that the machine thus obtained would be very light, very easy to fly, and would have a speed of 800 kph, i.e., substantially more than the series-produced Yak-3.

The MiG-9 fighter was the first series-produced jet plane designed by Mikoyan's design office. It was a single-seater, all-metal midwing monoplane.

* Kurt von Tippelskirch. Istoriya vtoroi mirovoi voiny (The History of the Second World War), p. 484. — Moskva, IL. 1956.

The plan view of the wing was trapezoidal. Two RD-20 jet engines with a thrust of 800 kg each were situated side by side in the lower part of the fuselage. The tricycle landing gear with nose strut provided an excellent view from the cockpit and greatly facilitated aircraft control in take-off and landing. The MiG-9 had powerful armament: one 37-mm cannon and two 23-mm cannons. Its take-off weight was 5000 kg, maximum speed 900 kph.

On 24 April 1946 pilot M. Ivanov made the first flight in a Yak-15, and that same day pilot A. Grinchik made the first flight in a MiG-9. In August both these first-born Soviet jet planes participated in the Tushino air display. After the display the Ministry of the Aircraft Industry was ordered to produce and fly before the anniversary of the revolution ten or fifteen Yak-15s and MiG-9s each. By 7 November 1946 all the planes were ready; however, the entire aerial part of the parade was canceled because of bad weather.

Muscovites saw first Soviet jet planes flying over Red Square on 1 May 1947. By that time a large number of Yak-15 and MiG-9 planes had been series-produced, and flights of jet planes had become an ordinary event.

The pilots regained confidence in jet aircraft.

In spring 1947 the test pilot General P. Stefanovskii performed aerobatics for the first time in a Yak-15, and the pilot I. Polunin showed aerobatics publicly in a Yak-15 at the Tushino display in 1947. Group aerobatics in jet aircraft were first displayed by five Yak-15s under the command of E. Savitskii, twice recipient of the Hero of the Soviet Union, at the air display in 1948.

Jet aircraft soon became an inseparable part of the daily life of the air force. This inseparability was not only because of the engineers and other employees of the aircraft industry but also of the test pilots. In 1948 the Presidium of the Supreme Soviet of the USSR conferred the title of Hero of the Soviet Union on four test pilots who had distinguished themselves most in mastering the new technique of flying jet aircraft: P. Stefanovskii, M. Ivanov, I. Fedorov, and I. Ivashchenko.

The measures outlined by the government determined the rate at which development of engine construction proceeded in the Soviet Union, and for this three stages were envisaged.

The first stage was transitional. To accumulate experience, captured German engines Jumo-004 with a thrust of 850 kg and BMW-003 with a thrust of 800 kg were to be used.

The second stage was the introduction in Soviet plants of British engines under license, the Derwent with a thrust of 1600 kg and the Nin with a thrust of 2200 kg.

The third stage was the boosting of work on Soviet jet engines by the design offices of V. Ya. Klimov, A. A. Mikulin, and A. M. Lyul'ka. A long-range view of all the engines was taken, and they were expected to develop thrusts from 3 to 8 tons.

The development of jet aircraft construction was also outlined in general and was put into effect in three stages during five or six years.

The first stage comprised aircraft Yak-15 and MiG-9, at that time already built with captured engines Jumo-004 and BMW-003 (Soviet designation was RD-10 and RD-20).

The second stage were jet planes with Derwent and Nin engines (Soviet designation RD-500 and RD-45). They were single-engined fighters MiG-15

(with RD-45 engines), La-15 and Yak-23 (with RD-500 engines) and the twin-engined bomber Il-28 (with RD-45 engines), of which prototypes were built in 1947—49 and then were immediately put into serial production. The three-engined bomber Tu-14 also was series-produced at this time.

The MiG-15 designed by Mikoyan's design office was the jet fighter produced in the largest numbers. The plane had swept wings* and empennage, a tricycle landing gear and a pressurized cabin. To permit abandoning of the aircraft at high speed, an ejection seat was incorporated. The jet engine, first an RD-45 with a thrust of 2270 kg, later a VK-1 with a thrust of 2700 kg, was located behind the pilot's cabin. Armament consisted of one 37-mm cannon and two 23-mm cannons. All three cannons and the ammunition for them were located in the fuselage on gun mounts which could be lowered. When necessary, additional fuel tanks or bombs could be suspended under the wings. The MiG-15 had a take-off weight of about 4800 kg and a speed of up to 1050 kph. The MiG-15s received their combat baptism in the Korean war and proved superior to the American F-86, the Sabres.

In 1948 tests began of Ilyushin's tactical jet bomber Il-28, which had a maximum speed of 900 kph and a range of 2400 km with a bomb load of 1 ton. Its defensive armament consisted of four 23-mm cannons. The plane weighed 21.2 tons. The Il-28 had tapered wings and a swept empennage. The two engines were mounted on brackets on the wings and covered by streamlined cowling, and the flexible-cell fuel tanks were located in the fuselage. The plane excelled by its simple and technological concept and was easy to pilot. The Il-28 was a worthy successor of the piston-engined bombers Pe-2 and Tu-2. It became the main tactical bomber of the Soviet army air force.

The third stage was the construction of planes powered by the first Soviet-made jet engines: fighters MiG-19, fighter-interceptors Yak-25 and bombers Tu-16.

The tactical fighter MiG-19, the first mass-produced Soviet supersonic aircraft, had a maximum speed of 1450 kph. Its swept wings were at an angle of 55°, and its elevator unit was fully tilting. The rear part of the fuselage contained two RD-9B engines, mounted side by side, with axial compressors. With reheat rating the engines had a thrust of 3250 kg. The fuel tanks were in the fuselage, but wing drop tanks were also provided. To shorten the landing run, brake parachutes were used. The controls of the aircraft incorporated many hydraulic boosters and electrical mechanisms. The MiG-19 was armed with three 30-mm cannons. Various additional armament could be suspended under the wings, thus broadening the possibilities of its tactical uses.

In the early fifties the design offices of Mikoyan, Lavochkin, and Yakovlev were given the task of designing the first Russian all-weather night interceptor. The MiG-190, La-200, and Yak-25 were built and tested. After tests for all aspects and a comparison of the flight and tactical characteristics, the Yak-25 was accepted for the armed forces. It was used as an all-weather interceptor for defensive patrols.

The concept of the Yak-25 offered many possibilities of further development and served as the basis for the most variegated versions of the Yak-28, series-produced supersonic combat aircraft.

* The first experimental plane in the Soviet Union with 35° swept wings was designed by S. A. Lavochkin.

A. N. Tupolev's Tu-16 was powered by two AM-3 engines, each with a thrust of 8750 kg, mounted laterally where the wings were joined to the fuselage. With a weight of 72 tons, the Tu-16 could carry a bomb load of 3 tons, having a range of 5760 km. Its maximum speed was almost 1000 kph. The six-man crew had powerful defensive armament, seven 23-mm cannons. Later the Tu-16 became a terrifying rocket carrier able to destroy ground targets without entering the enemy's air defense zone. Integrated into the military air force and made highly reliable, the Tu-16 was developed into the first Soviet jet passenger aircraft, the Tu-104, which is successfully operated by Aeroflot.

The rapid development of the construction of jet aircraft in the Soviet Union was due to the outstanding successes in producing jet engines. It should be pointed out that Soviet jet engines at that time did not have their equal in other countries, both regarding design and thrust.

This is briefly the history of the development of jet aircraft construction in the Soviet Union.

How different is all this from the legends propagated in the West in order to detract from the successes achieved by the Soviet Union and to imply that whatever the Soviet Union has was copied from the West!

In this respect the admission by the American Richard Stockwell in his book "Soviet Air Power" is not without interest:

"The Russians began demonstrating their jet planes as soon as they had been accepted as equipment by the armed forces in 1947. Western representatives saw them on Aviation Day in Moscow, and also in East Germany, in Poland and elsewhere. But nobody in the West attached much interest to the MiG-9 and Yak-15 planes... The rate at which the Russians developed their aviation in the late forties was simply astonishing, but nobody in the West took any notice."*

Further: "The speed with which the Russians put the MiG-15 into serial production was incredible, but what is even more astonishing is that nobody in the West appreciated this fact. At the end of 1949 large numbers of MiG-15 fighters could be found in East Germany. They appeared several times over Moscow. The military representatives of Western countries saw them and wrote about them in their reports, but none of them were greatly impressed by these planes."**

The Western authorities believed that "one might fear the Russian army but not their backward air force."†

Not until the Korean war, when some MiG-15 fighters engaged the latest North American Sabre jet fighters, did the Americans realize the preeminence of Soviet technical thinking in aviation.

The well-founded doctrine of development of aviation in the postwar period and the increased power of the Soviet aircraft industry yielded results. In the middle fifties the Soviet union had the following modern jet combat aircraft in large-scale production: MiG-19, short-range fighter; Yak-25, all-weather night fighter-interceptor; Il-28, tactical bomber; Tu-16, long-range bomber.

These planes formed the backbone of the air force up to the end of the decade when they were replaced by new or, better, faster planes with a

* [Retranslated from Russian.]

** Richard Stockwell. Soviet Air Power. New York. 1956. [Retranslated from Russian.]

† Ibid.

higher ceiling, which were shown at the air display at Tushino on 9 July 1961. This display was a creative accounting by the aviators to the Party and the Soviet people. It showed that in recent years the air fleet of the Soviet Union had been thoroughly modernized. Speed, range and ceiling of these planes were far greater. For the first time supersonic combat jet planes for various purposes were shown: fighters armed with air-to-air rockets, heavy rocket carriers with air-to-ground rockets, seaplanes or flying boats, special-purpose planes, a fighter with booster and others. All these were superfast, super-long-range planes with a superhigh ceiling on which at one time or another world records had been established. Complicated individual and group aerobatics testified to the skill of the pilots who handled these machines perfectly.

The display in 1961 showed the results of the revolution which had transformed aviation technology:

— the military air force of the USSR had become jet-powered;

— Soviet aviation had become supersonic. The speed of some fighters taking part in the display was almost three times the speed of sound;

— Soviet aviation was armed with rockets. The slow bombers were replaced by high-speed rocket carriers.

The planes were equipped with exceedingly good instruments, enabling them to fly throughout the year in any weather and to reach their target accurately.

The display in 1961 did not only show the achievements of the aircraft builders, but it also showed the gigantic effort by the Party and all the Soviet people.

It is significant that for several days after the parade the foreign press, and not only specialized journals, were filled with accounts of the air display. For obvious reasons the press of capitalist countries paid most attention to military aircraft. The scope and the high level of Soviet military aviation were completely unexpected by the West. They thought that the Soviet Union had devoted all its efforts and resources to the development of rockets and had lost interest in aviation.

The London Daily Mail printed an article by its scientific reporter Stevenson Pew, who had been at the Tushino parade. He wrote that the USSR showed new jet aircraft with supersonic speed ensuring the same primacy in aviation as in space exploration. Pew continued in his article saying that, deafened by the roar of aircraft, he felt like a little insect. At no display in America, France or Britain had he seen such skill as in Tushino. The display convinced the West that Russia was far from devoting all its efforts exclusively to rocketry.*

The New York Times drew attention to the jet planes with boosters and, referring to the opinion of Western experts, wrote that the United States has nothing that could compare in combat qualities with this Soviet aircraft. Referring to these same experts, the Swedish Svenska Dagbladet reached the same conclusion as the New York Times. **

The Austrian paper Neues Österreich exclaimed: "This was a display of military aviation the like of which the world had never seen before."

* Quoted in Pravda, 11 July 1961.

** Ibid.

And one more opinion. The Paris paper, Paris Presse Intransigeant wrote: "This was a shocking revelation. Until now it seemed that the Russians had completely switched to rocket construction, and the West thought it still had a considerable edge in piloted aircraft. In Tushino the Russians proved that they are able to divide their strength equally between exploring outer space and building aircraft such as they displayed yesterday. Their technical achievements came unexpectedly."*

The quality of Soviet aviation technology of 1961, displayed in Tushino, is clearly characterized by a number of great feats by Soviet flyers as to speed, altitude and range, achieved with new series-produced aircraft from among those which had so impressed Western observers.

In July 1959 V. P. Smirnov flew long-distance in an RV plane with a load of 2 tons at a steady speed and at an altitude of 20,200 m.

In October 1959 G. K. Mosolov flying an E-66 attained a maximum speed of 2500 kph and an average speed of 2388 kph over a 15 km — 25-km speed course.

In October 1959 B. M. Stepanov flying a 201-M plane lifted a load of 55.22 tons to an altitude of 13,000 m.

In 1959 outstanding successes were achieved in long-range flights with heavy aircraft when 17,000 km were covered without inflight refueling.

In April 1961 Mosolov in an E-66A plane attained an altitude of 34,714 m in dynamic flight. Also in 1961 Mosolov in an E-166 plane achieved a maximum speed of 3000 kph and 2681 kph on a 15 km — 25-km speed course.

The excellent qualities of aircraft in the late fifties and early sixties were not only the result of the work of the special design offices of the renowned general and chief designers. Much of the credit must go to the research institutes — TsAGI, VIAM, and others — where important problems of supersonic aerodynamics and strength of aviation materials were investigated by the foremost scientists, among them in first place Academicians V.V. Struminskii and S.T. Kishkin, and Corresponding Member A.I. Makarevskii; this enabled the designers to build aircraft of such high quality.

The five years since 1961 are marked by further outstanding achievements of Soviet aircraft construction. At the 23rd Party Congress the Minister of Defense spoke of the new and modern planes supplied to the air force. He especially pointed out that new and highly efficient complexes of interceptor planes had been created and supplied to the forces; qualitative changes had been made in long-range aviation; a considerable part of tactical, sea, rocket-carrying, and especially of military transport planes had been replaced by more modern models.

The air display in Domodedovo on 9 July 1967 was convincing evidence of this rapid progress. It was a demonstration of the quality that Soviet aviation had achieved on the 50th anniversary of Soviet power.

The program of the display proved that aviation science and practice in the USSR had achieved new successes in the six years since 1961. Planes which in 1961 had been shown only as prototypes flew in entire squadrons, piloted by rank-and-file military airmen.

The latest technical achievements were also demonstrated. V. Mukhin flew the first Soviet VTOL jet plane. This aircraft, powered by two turbojet engines with swiveling nozzles and with a system of jet control, does not

* Quoted in Pravda, 12 July 1961.

need any concrete runway; it can take off and land on the tiniest patch. The combination of high speed and this unique take-off and landing performance offers aircraft completely new potentialities.

The problem of vertical take-off and landing has for a long time challenged the skill of aircraft engineers all over the world. There are various principles which enable aircraft to take off from confined spaces, but so far only three or four of these projects have been actually realized. The possibility of building such aircraft was given by the advent of sufficiently powerful and light turbojet engines. Vertical take-off requires that the thrust of the engine exceed the weight of the aircraft. In the Soviet plane the jet stream of the engine is deflected downward by special swiveling nozzles, thus directing the thrust into a vertical direction. When the aircraft has reached a sufficient altitude, the pilot gradually turns the nozzle into a horizontal position, thus changing the direction of the exhaust gas stream and accelerating the aircraft. In landing everything occurs in reverse order.

Other novelties were two supersonic planes which changed the shape of their swept wings while in flight. For take-off, landing and long flights the wings are opened up to a small angle of sweep; for attaining a higher speed the angle of sweep is increased.

Construction of aircraft with variable angles of sweep was made necessary by two apparently irreconcilable requirements: very high flying speed and low landing speed. Wings with a large angle of sweep have the smallest resistance in high-speed flight but do not ensure sufficient lift for take-off and landing. Aircraft with such wings have a high landing speed, making piloting difficult and requiring long runways.

A principle of combining low landing speed with high maximum speed by changing the wing shape was proposed by an engineer named Makhonin already before the war. The actual solution to the problem, however, was not put into effect until the mid-sixties when the first viable designs incorporating this principle appeared.

When designing Soviet planes with a variable angle of sweep, many complicated technical problems had to be solved. The main difficulty was to find an aerodynamic configuration which would ensure stability and controllability of the aircraft within the entire range of change of the wing angle of sweep. It was necessary to combine two types of aircraft, a low-speed airframe and a high-speed fighter. The display in Domodedovo proved that it was not beyond the Soviet designers to solve this problem.

Both the VTOL aircraft and aircraft with a variable angle of sweep testify to the successfulness of design offices and research institutes to find the solution of difficult problems confronting modern aviation.

Interesting was also the display of fighters with lifting engines located in the fuselage, which shortened take-off and landing runs, and new fighter-interceptors of an original configuration.

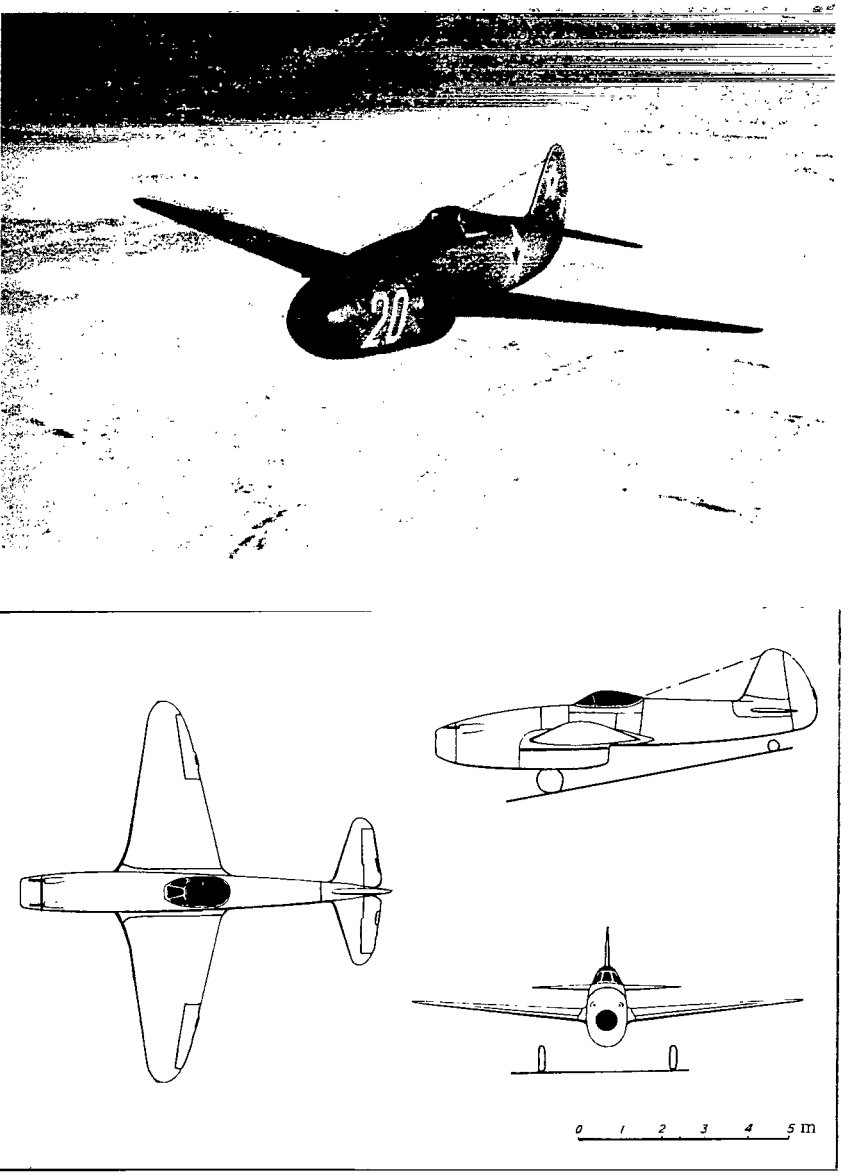
The demonstration of the planes designed by O. K. Antonov's design office was effective. An-12 planes dropped parachutists; more than one thousand men with full combat equipment landed on the airfield. A lucid illustration of the progress achieved in civil air transport was the fly-past of passenger jet planes. The first was the veteran Tu-104, and then followed more modern liners, the Tu-134 and the Il-62, which landed with reverse thrust, and the Yak-40, the first jet plane for local air transport.

As always, sports pilots of the All-Union Voluntary Society of Cooperation with the Soviet Army, Air Force and Navy (DOSAAF) and military pilots took part in the display and demonstrated aerobatics in the Yak-18P sports planes and supersonic MiG-21 fighters.

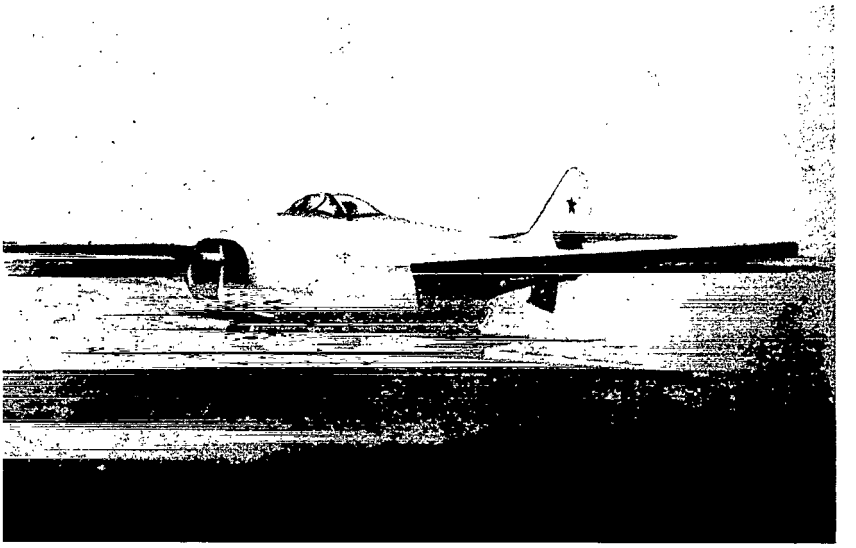
The air display aroused much interest among foreign aviation specialists, and the Soviet and foreign press were unanimous in praising Soviet successes. The representative of France Presse wrote: "All Western specialists agree unanimously that Russian technology has reached a high level. Most specialists believe that such high quality could be achieved only thanks to a broad network of research institutes and laboratories and the existence of a first-class industrial base in aircraft construction."

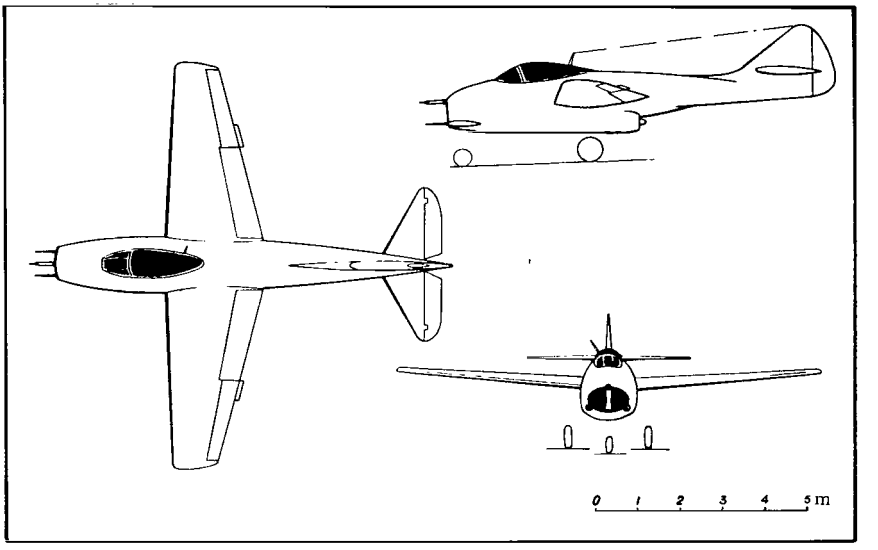
Soon after the display many world records, achieved in the new planes, were announced. For instance, Hero of the Soviet Union A. Fedotov attained on 5 October 1967 an altitude of 30,010 m with a load of 2 tons. M. Komarov attained an average speed of 2930 kph in a 500-km closed circuit. P. Ostapenko attained an average speed of 2910 kph with a load of 2 tons on a 1000-km closed circuit. All these records were achieved in series-produced single-seater E-266 interceptors designed by A. I. Mikoyan.

The newspaper Pravda wrote on 10 July 1967: "Yesterday's air display was evidence that aviation has become an inseparable part of the Soviet army and navy, that it is on the required level both regarding equipment and the training of the flying personnel, that it is ready hand in hand with the other units of the armed forces to fulfill the most difficult tasks for reliably protecting the country against any aggressor."

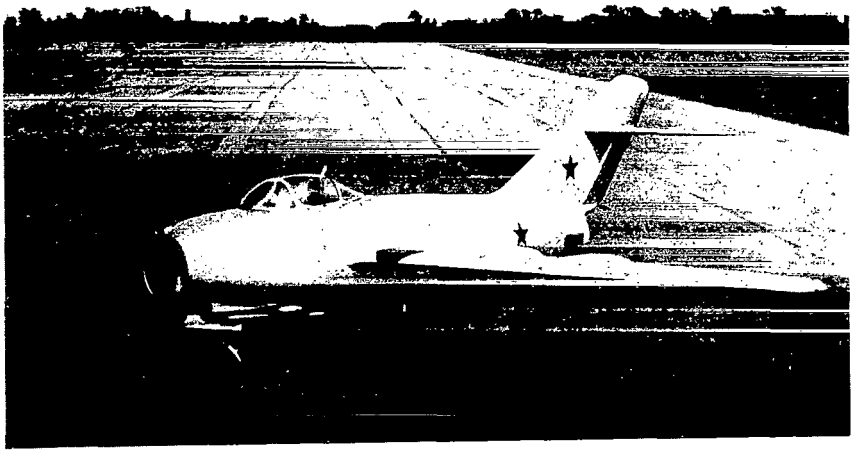


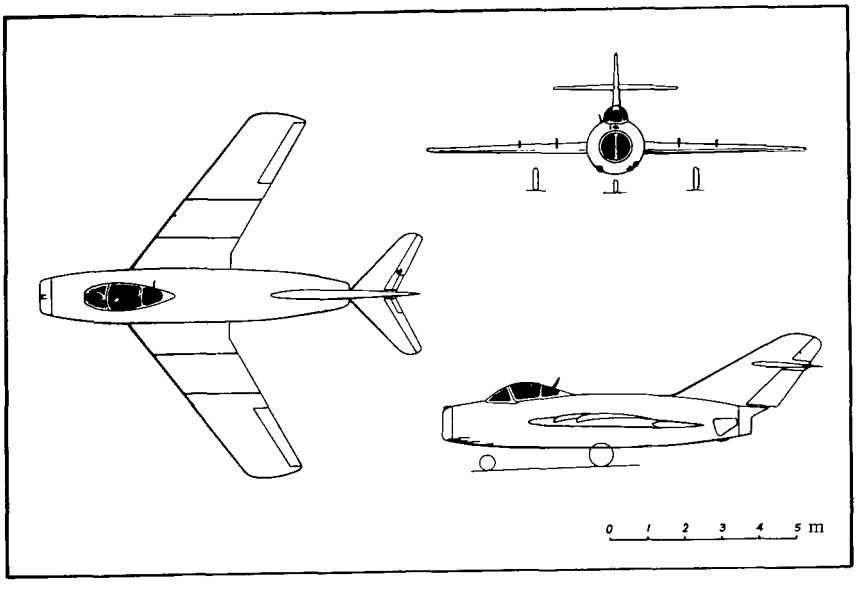
Fighter Yak-15.



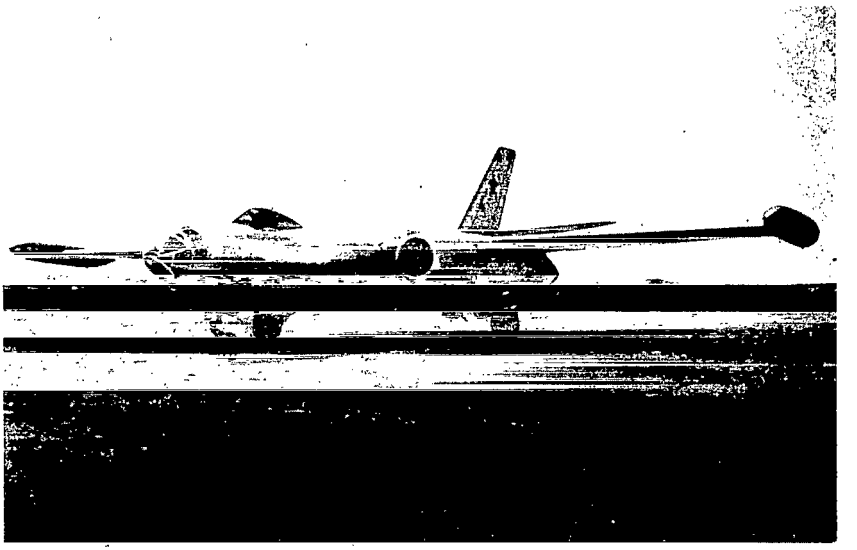


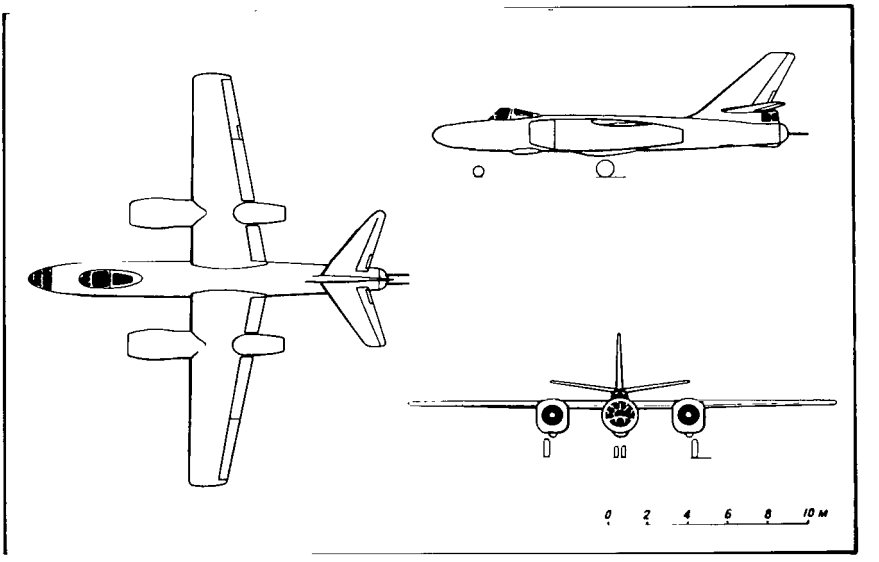
Fighter MiG-9.



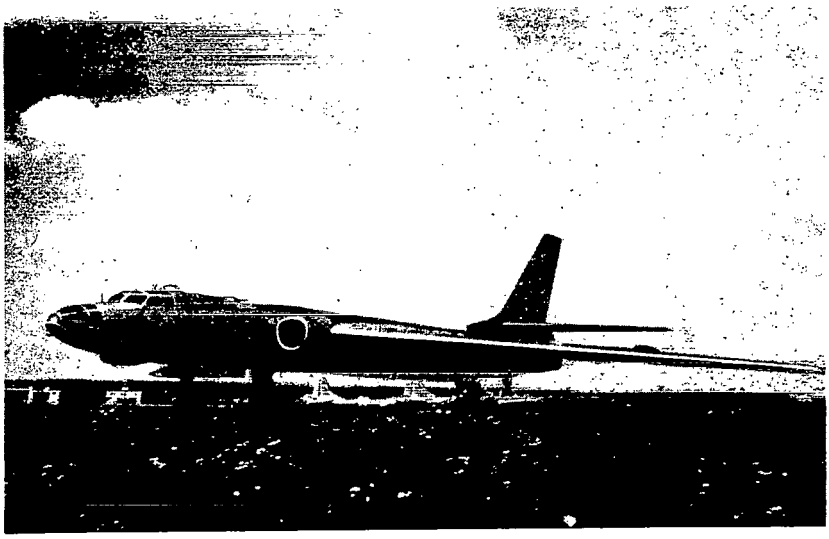


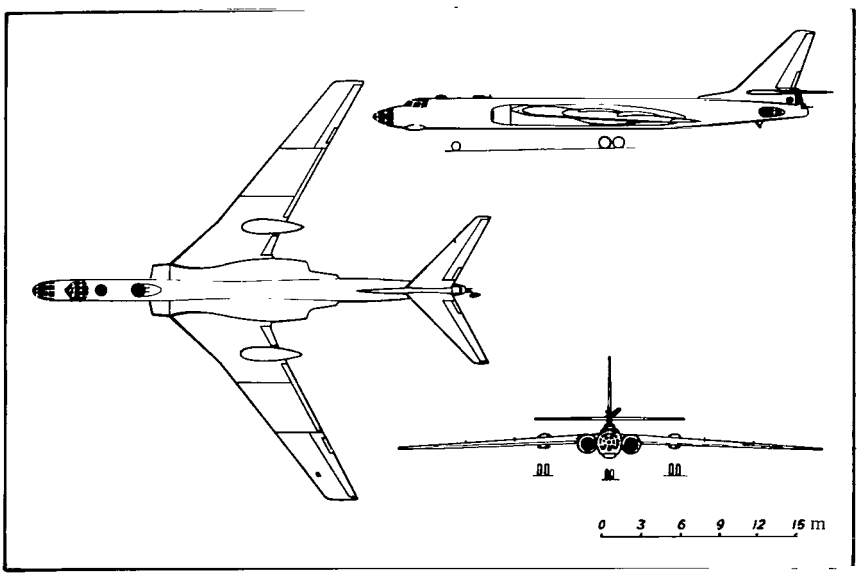
Fighter MiG-15.



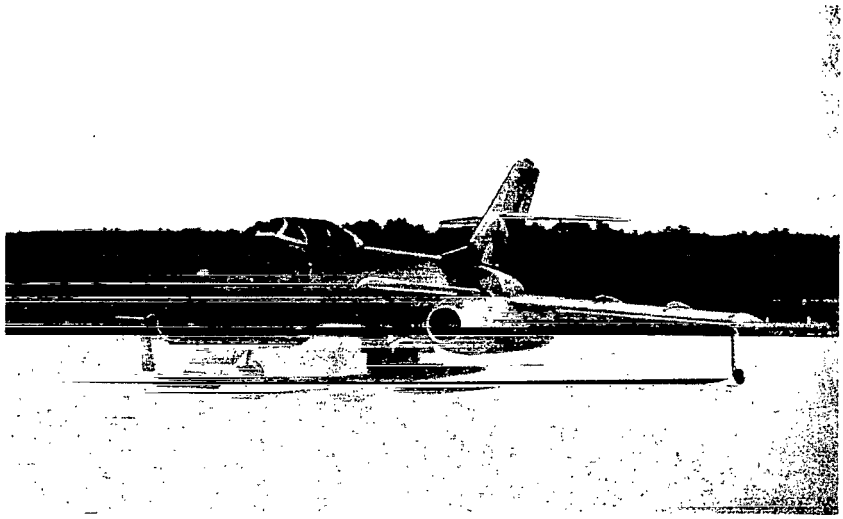


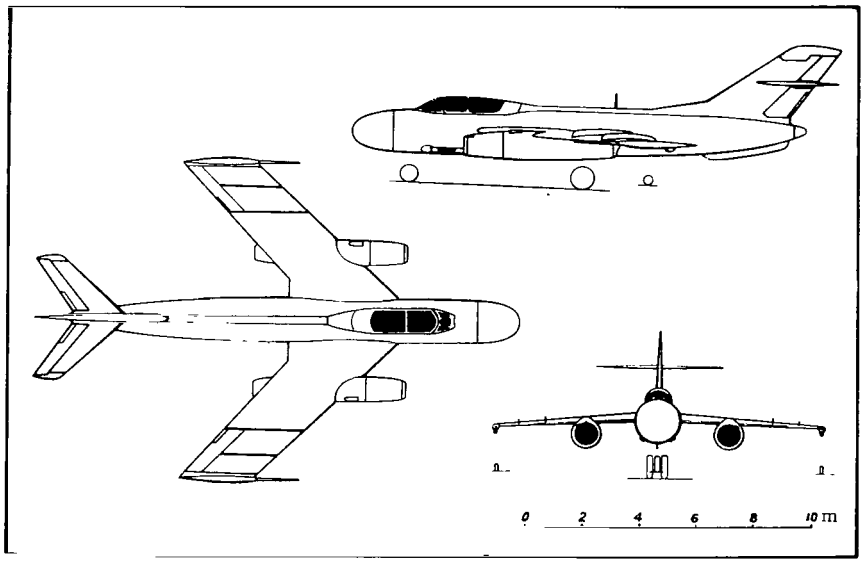
Tactical bomber Il-28.



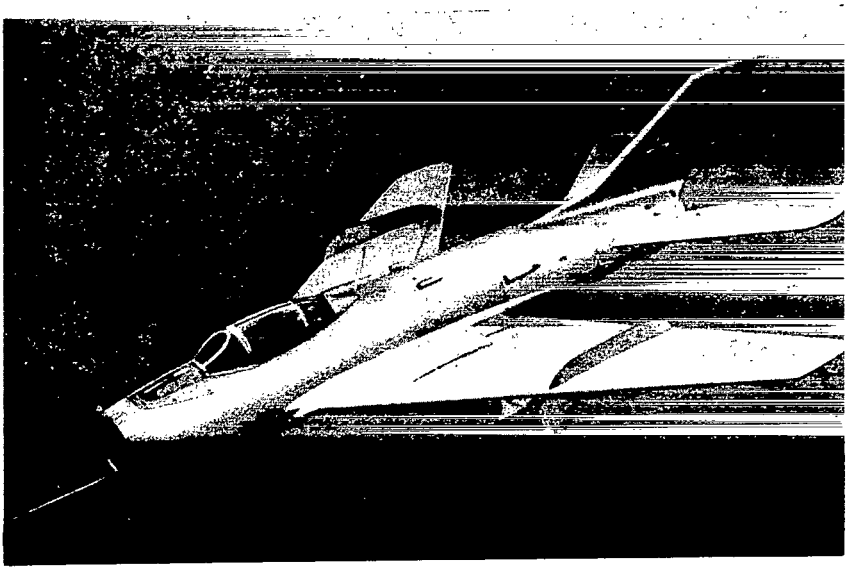


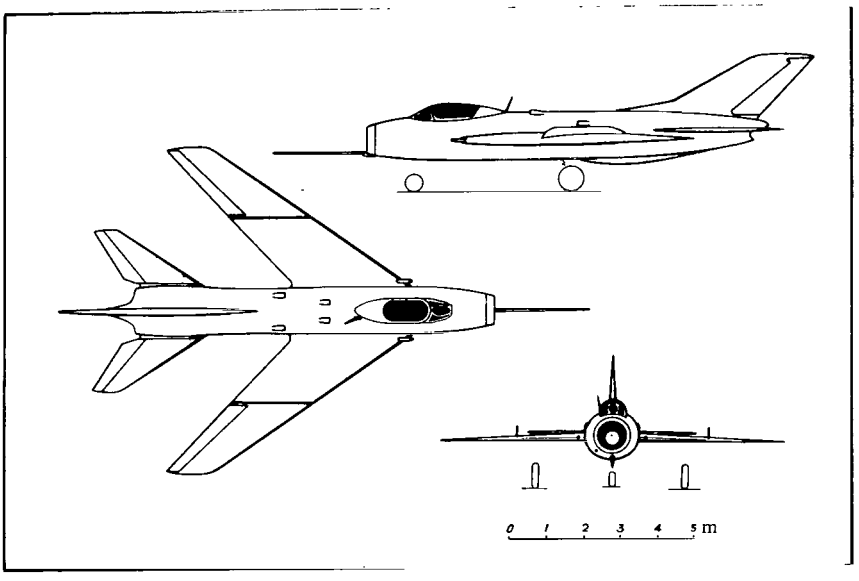
Long-range bomber Tu-16.



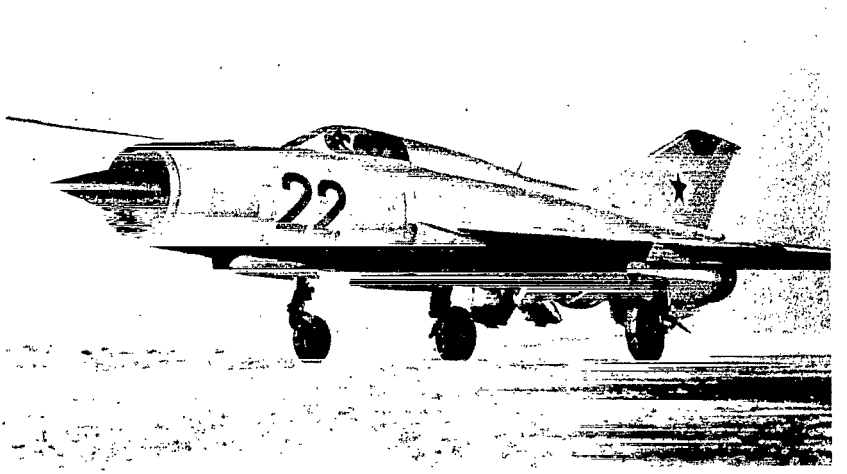


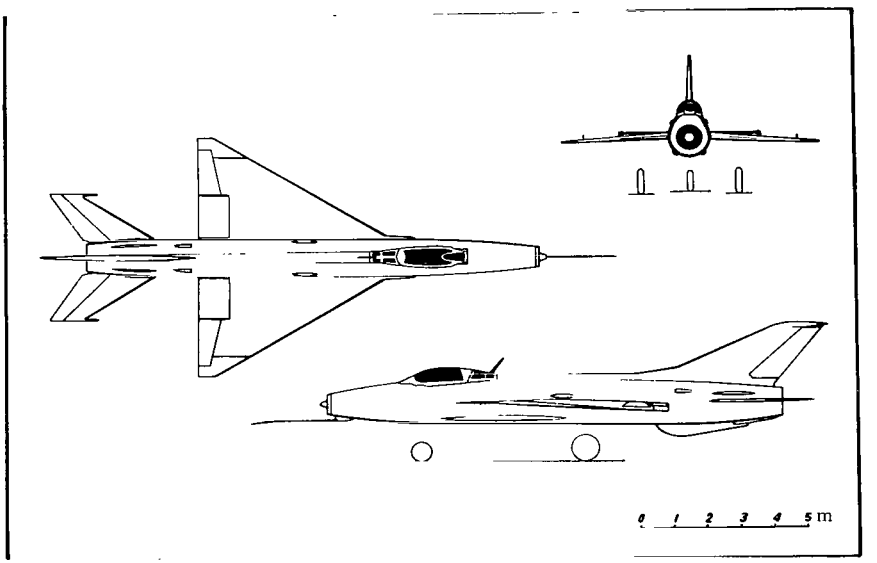
All-weather interceptor Yak-25.



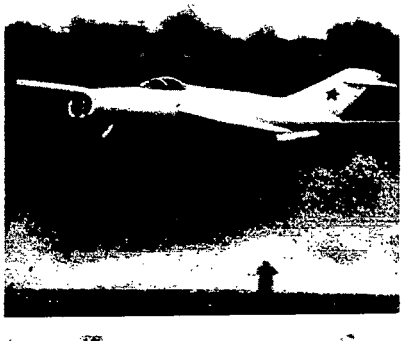


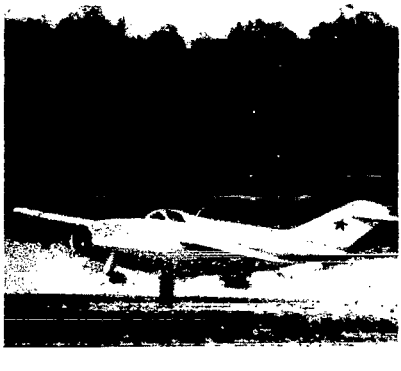
Fighter MiG-19.



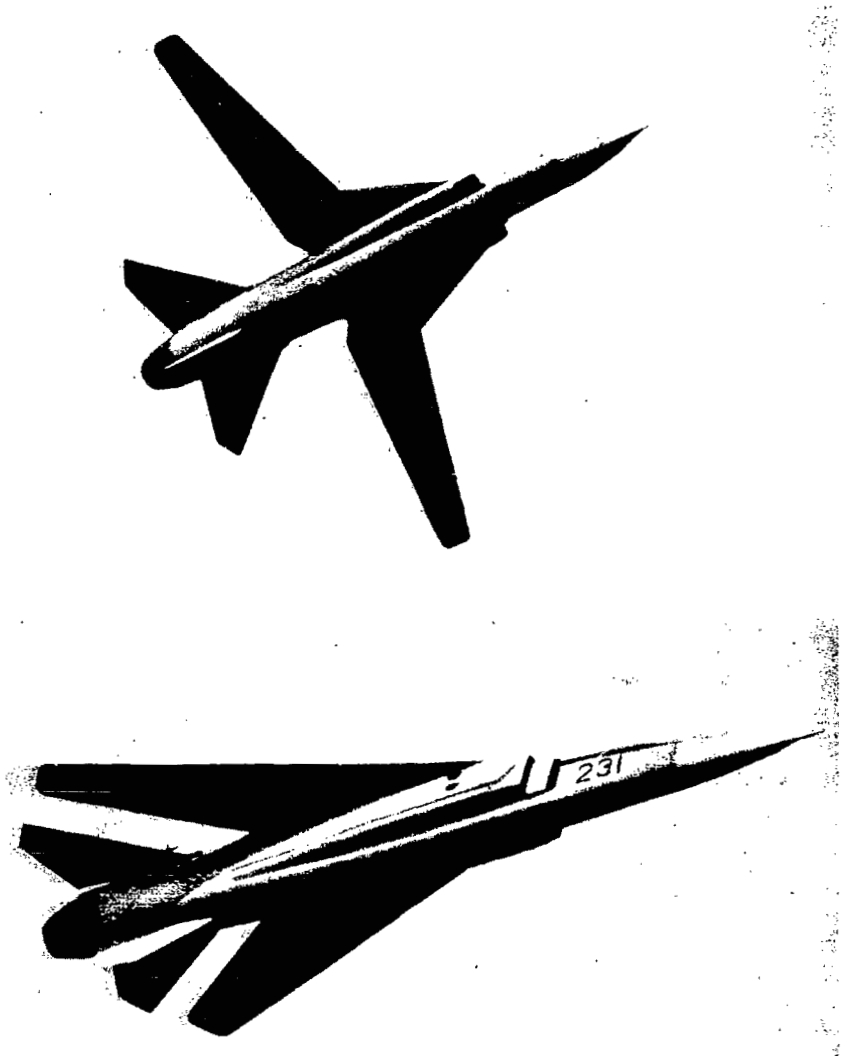


Fighter MiG-21.





VTOL jet fighter. Air display in Domodedovo, 1967.



Multipurpose jet aircraft with variable wing shape. Air display in Domodedovo, 1967.

8. *SPORTS PLANES*

In the first years of Soviet power the Party encouraged in every conceivable way the development of sports flying.

The foundation was laid for the mass production of light aircraft for training airmen.

The organization of sports flight in the country gained much publicity. Through aeroclubs the youth of the country joined in building the aerial might of the country. The achievements in sports flying were the contribution of the young generation.

Sports flying was the school for many heroes of World War II and renowned pilots holding world record. Sports flying was also the initial start for many outstanding aircraft designers, the creators of the powerful combat planes.

In Soviet aircraft construction a special place belongs to the creation and development of sports flying. It played a role in developing Soviet designers and in training pilots for the army and civil aviation.

Sports flying provided the entry into real aviation for the designers S. V. Ilyushin and O. K. Antonov, the famous rocket designer S. P. Korolev, the renowned Soviet aerodynamics specialist V. S. Pyshnov and many others.

In the USSR low-powered aviation was born in 1924—25 when interest in sports flying was aroused among military and aviation specialists.

Progress of aviation — increase in speed, range, ceiling, lifting power — was marked by constant increase in engine power. The first airplanes at the beginning of the twentieth century had engines of 25 hp—30 hp. As early as halfway through the second decade, however, when aircraft found widespread use in World War I, the power of aircraft engines increased rapidly. Whereas at the beginning of the war engine power was 40 hp—60 hp, toward the end of the war it attained 250 hp—400 hp. Only ten years passed, and in the fall of 1927 the British hydroplane Supermarine, which at the international aircraft race in Italy established a world speed record of 453.85 kph, was already powered by a 1000 hp Rolls Royce engine.

Since the power of military aircraft was increased to attain maximum speed, the highest possible ceiling and other tactical characteristics, production and operating costs of the planes were not of decisive importance. However, a field of aviation such as sports flying required economical, low-powered planes. Sports flying, which spread in almost all European countries after World War I, could not progress using existing military aircraft. In the early twenties a return to aircraft with low-powered engines therefore started. Attempts were made to increase flight performance mainly through improved aerodynamics.

To supply the network of aeroclubs and civil flying schools, inexpensive planes were needed, ones simple in design and cheap to operate. Small planes appeared, with engines of 18 hp, 30 hp, 60 hp, up to 100 hp, fulfilling these requirements. Thanks to their inexpensiveness, small dimensions,

dual control, maximum simplicity of maintenance, low weight while able to fly at 150 kph to 200 kph, such planes found widespread use throughout the world.

The use of low-powered aircraft was not confined to clubs and flying schools. They were also used in military air forces as communications aircraft and for training pilots.

Since Soviet engine construction only made its first tentative steps in the twenties, the designers of low-powered aircraft had to begin with obsolete Ansani engines of 35 hp, left over from World War I, or to adapt 12 hp Harley motorcycle engines. The first Soviet light plane was built by a military pilot and a flying-school instruction, V. O. Pisarenko; it was built at his expense and powered by an Ansani engine. Although the plane had been built under very difficult conditions, almost without any computations, it did not fly badly.

This same Ansani engine also powered A. N. Tupolev's first aircraft, the ANT-1.

V. P. Nevdachin built his light plane "Burevestnik" with a Harley motorcycle engine. It carried out several flights over the Moscow aerodrome, piloted by A. I. Zhukov.

The Soviet designers gained more confidence when Osoaviakhim ordered several engines from abroad: Blackburn, Bristol-Cherub, and Cirrhus of 18 hp, 30 hp, and 60 hp, respectively. However, the work done at that time was still unsystematic.

Low-powered aircraft were built mostly in amateur circles, by members of Osoaviakhim groups at plants and schools, without appropriate equipment and instruments. Sometimes they had to use discarded aircraft materials and parts of old military aircraft. The lack of means to work according to rather rudimentary blueprints made it necessary to make changes even while the aircraft were being built.

Nevertheless, since 1925 the Soviet Union has obtained completely new designs. Second to the light planes built by Pisarenko, Tupolev, and Nevdachin, the most successful light plane, from the point of view of flight characteristics and design, was the single-seater RAF-1 with a Blackburn engine, built by a student of the Military Air Force Academy, A. N. Rafaelyants. It was as good as the famous British light plane De Havilland DH-53. It carried out several successful flights.

In 1926 several clubs in different towns simultaneously built light sports planes. The first among them made a light, two-seater biplane AIR-1 with a Cirrhus engine. This plane, like the subsequent AIR planes, was built at the Military Air Force Academy according to the design by A. S. Yakovlev (then an engine specialist of the flight detail of the academy). When it was established that the plane had good flight characteristics, it was sent in June 1927 on a roundtrip flight from Moscow to Sevastopol, which was carried out successfully by Yu. I. Piontkovskii. While en route he set two world records for sports planes. After this flight low-powered aviation aroused general interest and attention.

Also in 1927 V. P. Nevdachin completed the "Burevestnik" S-4, powered by a Blackburn engine. The Burevestnik had outstanding flight characteristics, and on one test flight A. I. Zhukov broke the world altitude record when he reached 5000 m.

The successes achieved by the AIR planes and by the Burevestnik gave a further impetus to the development of low-powered aviation. Osoaviakhim provided the necessary funds. The design and operational characteristics of aircraft improved. At the Berlin aviation exhibition the Russian light planes "Burevestnik," designed by Nevdachin, and "Three Friends" designed by Sutugin, Gorelov and Semenov received commendation.

Between 1927 and 1929 several other light airplanes were built in Moscow, Leningrad, Kiev, Kharkov and other towns.

At that time the two-seater monoplane AIR-3 was also designed. The necessary money was collected by pioneers, and the plane was built at the Aviarabotnik plant. It was called Pionerskaya pravda. On 6 September 1929 this plane carried out a nonstop flight from Mineralnye vody to Moscow. The distance of 1750 km was covered at an average speed of 170 kph. With this flight students of the academy, the sports flyers Filin and Koval'kov, established two world records — length of nonstop flight and average speed over a distance of 1750 km.

The year 1929 was memorable, because another three light airplanes also made their appearance.

V. B. Sharov, an engineer, built a light amphibious aircraft, Sh-2, powered by a Walter engine. The Sh-2 flew from Leningrad to Moscow, taking off from the water and landing on an airfield. This excellent model was afterwards built in large numbers and was extensively used in various branches of the economy.

That same summer a new single-seater light plane, the G-1, with a Blackburn engine, designed by the famous glider pilot V. K. Gribovskii, was tested. The plane had excellent characteristics.

The young Soviet designers proved that they were able to build modern sports planes. At first, however, the development of low-powered aircraft was impeded by the lack of light Soviet-made engines. In view of that Osoaviakhim ordered from abroad a small number of 60 hp and 80 hp Walter engines, with which several new designs were worked out. Among them were three planes, type AIR-4, with a 60-hp Walter engine. This was a greatly improved modification of the AIR-3.

In October 1929 Osoaviakhim organized a roundtrip flight on an AIR-4 over a distance of 3650 km on the route Moscow—Kiev—Odessa—Sevastopol—Moscow. The pilot was again Piontkovskii.

The results of the first long-distance flights clearly showed the achievements of Soviet sports flying. Nevertheless there was a proposal to import several light planes of different types and to copy them. This proposal was unjustified, because several Soviet light planes were in design with flight characteristics as good as foreign planes.

The rate of technical progress in light sports planes was about the same in the Soviet Union as in other countries. As in the West, the Russians, too, had to pass through stages of gradual increase of engine power from 10 hp to 60 hp. The fairly great initial enthusiasm for low power was soon abandoned. Designers changed their views and correctly started building planes with engines of 60 hp, 80 hp, and even 100 hp.

In the late twenties and early thirties the Soviet Union was already committed to mass production of low-powered aircraft. Their widespread introduction was stimulated by the construction of the excellent Soviet aircraft M-11 engine of 100 hp, designed by A. D. Shvetsov. In 1927 it was fitted

into the two-seater, trainer biplane U-2, designed by N. N. Polikarpov. The U-2 was tested by M. M. Gromov.

The plane built on the occasion of the tenth anniversary of the October revolution was a beautiful present for Soviet aviation, which it served for more than thirty years. The plane was of simple design; the frame was made of pine laths, braced by wire and covered with canvas. The upper and lower outer wing panels were alike in shape and size, facilitating production. Unusual at that time was the large empennage, resulting from the serious study the designer had made on the problem of spin.

The flight characteristics of the U-2 were extremely valuable in a training plane. It allowed for even grave piloting errors. By itself the plane did not go into spin; and when spin was deliberately induced, the plane recovered automatically when the stick was released. With the engine switched off the plane had a rate of descent of 1—2 m/sec, i.e., much less than the speed of a parachutist. When the angle of attack was too great and the U-2 lost speed, the nose was automatically lowered and the plane gained speed again. Altogether, the U-2 was an easily controlled and safe plane with great lifting capacity, easy for take-off and landing, and with a low landing speed. It maintained these qualities in all its versions and modifications. Its equipment changed and its design was updated, but its shape and dimensions remained on the whole unchanged. There were no major changes in its characteristics either. The weight was and remained about 1 ton (except the armed version), maximum speed was about 150 kph, landing speed 70 kph, take-off and landing run about 100 m.

The U-2 was designed for the primary training of pilots. Soon, however, it was also used as a liaison aircraft, as transport or ambulance aircraft, in agriculture, for aerial photography, for patrolling forests, and so forth. That the plane could be used for so many different tasks was due to its great lifting capacity and the all-purpose design. During the war the light night-bomber U-2VS was particularly used. It was armed with a machine gun and could carry 300 kg of bombs. Equipped with a muffler, the plane flew noiselessly over the enemy positions and efficiently destroyed men, fuel and ammunition dumps, and vehicles. The U-2 ensured continuous liaison with partisans or it was used for short-range reconnaissance. It served as night artillery spotter (version U-2NAK), as a propaganda plane with a powerful loudspeaker (version U-2GN — "Voice from Heaven"), as a staff or liaison aircraft (five-seater U-2ShS).

After N. N. Polikarpov's death in 1944 the U-2 was renamed Po-2 and was produced as such. After the war a modernized agricultural version, the Po-2A, was produced and the three-seater limousine Po-2L. In all, approximately 33,000 planes in different modifications were produced. As to length of production run and universal applicability, the U-2 had no equal in world aviation.

In the early thirties a small group of young public servants, who were aviation enthusiasts, worked in the Menzhinskii plant on the design of new sports and light planes; the funds necessary for construction had been released by Osoaviakhim. In 1932 the three-seater limousine AIR-6 with a series-produced M-11 engine was built here. After testing the plane was put into series production and found widespread application in the economy.

At that time Osoaviakhim organized a competition for the design of a light plane. First prize was awarded for an electron (magnesium-based alloy)

plane and second prize for a stainless steel plane, i.e., both materials that were in very short supply at that time. What the country really needed was a plane made of amply available and cheap material, i.e., wood, simple to fly and reliable.

The development of light aircraft was in the beginning publicized effectively by Pravda. In August 1934 together with Osoaviakhim the newspaper organized the first great sports flights of a group of AIR-6 planes on the route Moscow—Irkutsk—Moscow. The flight was successful and was described by Pravda as the beginning of mass participation in light aviation whose development has a good chance in the USSR.

In the leading article on 25 August 1934 under the title "Sovetskii vozdushnyi ford" (A Soviet Flying Ford) Pravda wrote:

"There is general interest in light aircraft. This cannot be otherwise, for the need of them is obvious to everybody. A light aircraft is needed for regional and district organizations to provide quick and reliable connection with any point in a region or district. Economic authorities need light planes for operative management of subordinate enterprises. The light plane is viewed with envy by our young members of aeroclubs who need planes for training, publicity and tourist flights. Light planes are needed but not provided for local lines of our civil aviation... Low-powered aircraft make it possible to attract broad strata of the population to aviation. The cultural value of mass flights in light planes is immeasurable. It also has a great role to play in strengthening national defense. To saturate the country with light planes, such is the urgent task...

"The ball is now with the industry which must provide for serial production of light planes...."

Development of all kinds of sports flying in the country was boosted in the thirties by the network of aeroclubs which had been built up. Here future pilots, parachutists, glider pilots and technicians of the air force were trained and selected.

To unite all the work connected with sports flying in Moscow at the Tushino airport, the Kosarev Central Aeroclub was founded in March 1935. The aeroclub initiated parachute and glider sports competitions, began flights on low-powered aircraft and inspired aviation records. The Central Aeroclub was also the focal point for all designers. The aeroclub registered records of such pilots as V. P. Chkalov, M. M. Gromov, V. K. Kokkinaki and many others.

In 1935 Pravda and Osoaviakhim organized an All-Union flight of training and sports planes on the circular route Moscow—Gorkii—Kazan—Sarapul—Perm—Sverdlovsk—Orenburg—Kuibyshev—Saratov—Stalingrad—Lugansk—Stalino—Dnepropetrovsk—Kiev—Bezhitsa—Moscow. In addition to the twenty series-produced U-2 and AIR-6 planes, other training and sports planes participated in the flight. They were newly designed and represented aeroclubs, the sports aviation of the Red Army, the civil aviation fleet, the Gorki propaganda squadron, and the association "Dinamo." First place in the flight went to Piontkovskii who had been flying an AIR-10.

The Central Committee of the Party gave much attention to the problem of training personnel for flying. On 12 July 1935 a demonstration of the achievements of the members of the Central Aeroclub was organized in Tushino for Party leaders. This day marked the turning point in the fate of Soviet sports flying. Soon after the display at which an AIR-10 was the victor

among all the participating sports planes, this aircraft under the designation UT-2 (trainer, two-seater) underwent government tests and was accepted for the air force as a primary trainer aircraft for flying schools and aeroclubs. For ten years, beginning in 1936, the UT-2 monoplane with dual control was the main primary trainer aircraft. Many thousands of pilots, among them the heroic pilots of World War II, received their first training on it.

In 1936 a single-seater sports training plane, the AIR-14, was produced. It was later designated UT-1 (trainer, single-seater). This monoplane powered by an M-11 engine was intended for advanced flight training, for training pilots in aeroclubs, and for military air force schools. The plane passed its tests successfully and was put into serial production.

Thanks to the support by the Central Committee of the Party and the Soviet government great strides had been made in low-powered aviation in the Soviet Union by 1937. An eloquent testimony of this fact was the display of new low-powered sports planes held at the Tushino aerodrome on 6 May 1937. In the fly-past planes UT-1, UT-2, G-22, G-23 and others took part. Great interest was aroused by the G-23 which was powered by an automobile engine of the Gorki Automobile Works. The designer and pilot V. K. Gribovskii himself flew the plane.

Soon air races were organized on the route Moscow—Sevastopol—Moscow, a distance of 2815 km. The races were a stringent test of the state of Soviet low-powered aviation. The best results achieved were: in single-seaters by the pilots Il'in and Dymov in UT-1 planes, in two-seaters by pilot Stefanovskii and navigator Nikitin in a UT-2, and by pilot Malakhov and mechanic Volokitin in a G-20.

The results of the flight strengthened the reputation of low-powered aircraft, and the large-scale production of U-2, UT-1 and UT-2 planes gave hundreds of thousands of young people the chance to join the military air force via sports flying. There was a huge influx into flying and technical aviation schools.

Further development of training and sports flying in the country was effected by basing training aircraft on combat aircraft. The UT-2 was in 1946 replaced by the two-seater training and sports plane Yak-18. This plane (first with an M-11 engine, then with an AI-14) had retractable landing gear, an enclosed cockpit, controllable-pitch propeller and a fair amount of instrumentation, including a two-way radio.

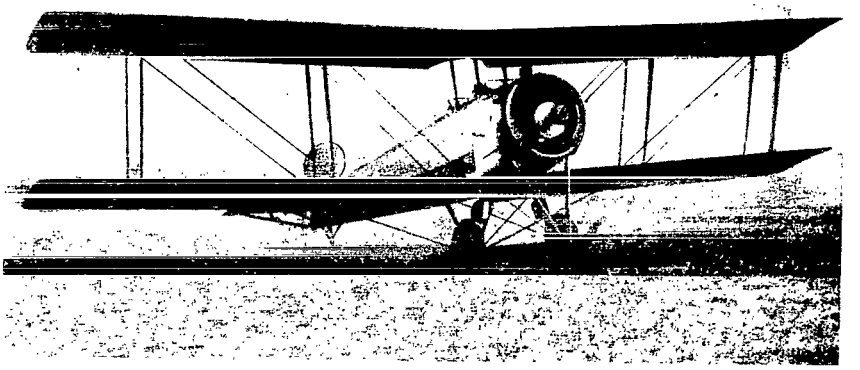
Finally, in 1960, jet-powered training planes, such as the two-seater Yak-30 and the single-seater Yak-32, with a RU-19 engine, designed by S. K. Tumanskii, were produced. With these planes the sports pilots G. Korchuganova, R. Shikhina, V. Smirnov and V. Mukhin established world records for the corresponding class of sports planes.

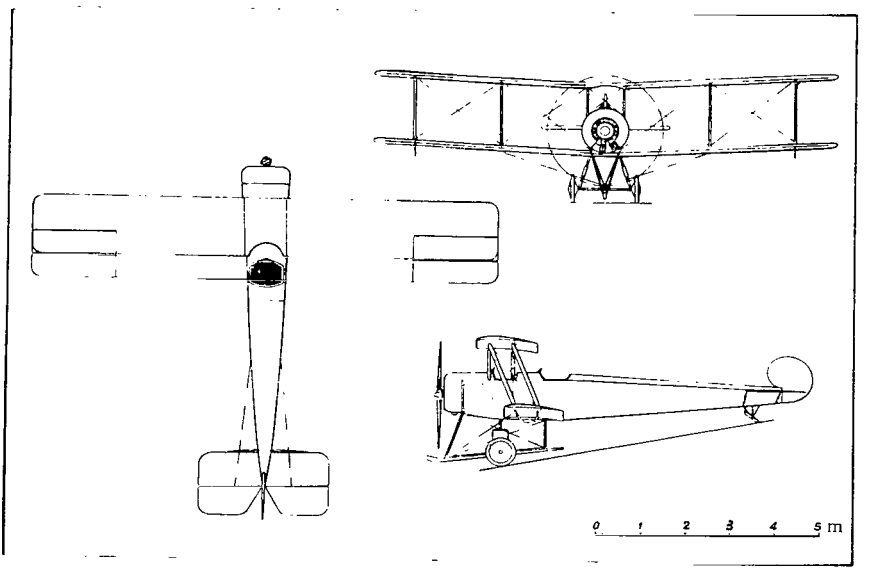
In August 1966 in Moscow at the International Aerobatics Competition the sports pilots G. Korchuganova and V. Martem'yanov in Yak-18PM planes won the title of world champions, and the Yak-18PM was named the best sports plane.

Low-powered aviation was firmly established. It had become a public sport of national dimensions.

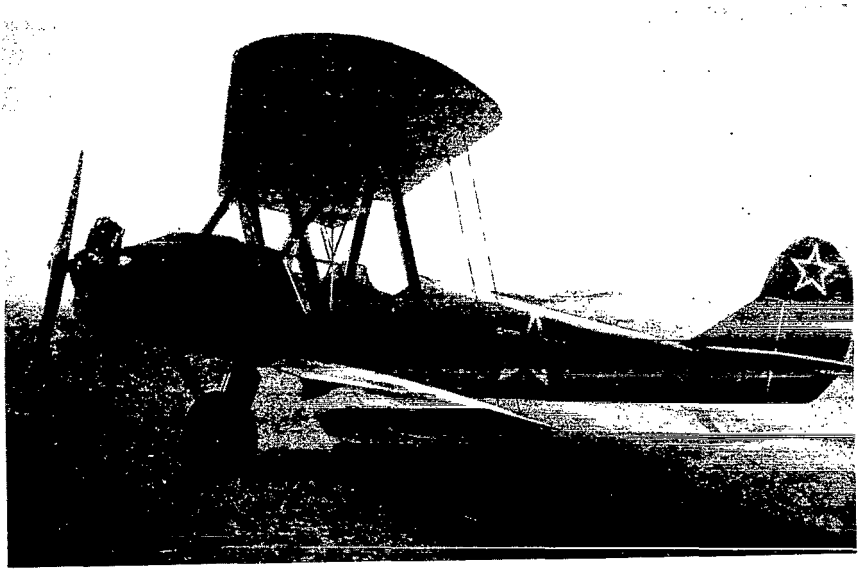
Trainer aircraft

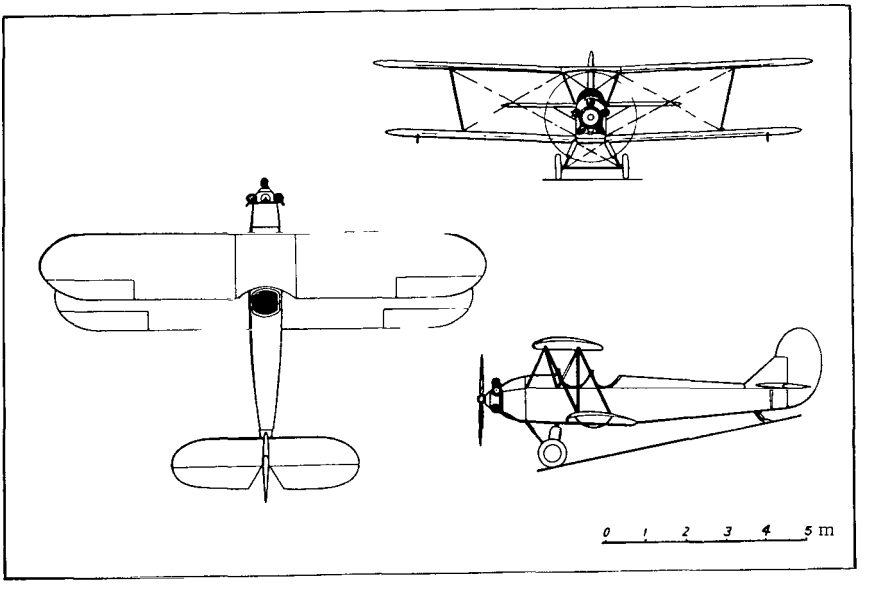
Type of aircraft	Year of production	Engines (type, number, power or thrust)	Take-off weight, kg	Fuel tank capacity, kg	Crew	Maximum speed, kph	Range, km	Altogether produced
U-1 (Avro 504K)	1922	M-2, 120 hp	840	53	2	140	195	737
U-2 (Po-2)	1927	M-11, 100 hp	983	90	2	146	430	33000
Sh-2	1930	M-11, 100 hp	937	87	2	139	450	700
UT-2	1935	M-11, 100 hp	856	56	2	210	750	7243
UT-1	1936	M-11E, 150 hp	590	68.5	1	257	670	1241
Yak-11	1946	ASh-21, 570 hp	2418	270	2	456	1290	3859
Yak-18	1946	M-11FR, 160 hp	1060	112	2	245	1095	6760
Yak-18A	1957	AI-14R, 260 hp	1316	95	2	254	710	Yak-18 of all modifications
Yak-30	1960	RU-19, 900 kg	2250	500	2	660 (record 767)	965	6
Yak-18PM	1965	AI-14RF, 300 hp	1110	50	1	320	400	



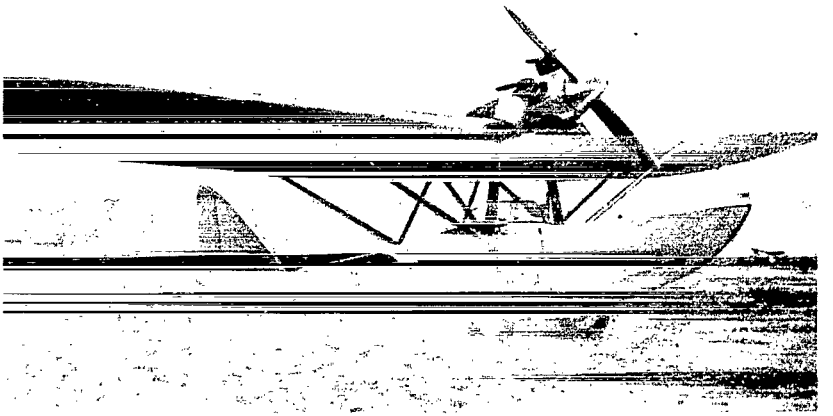


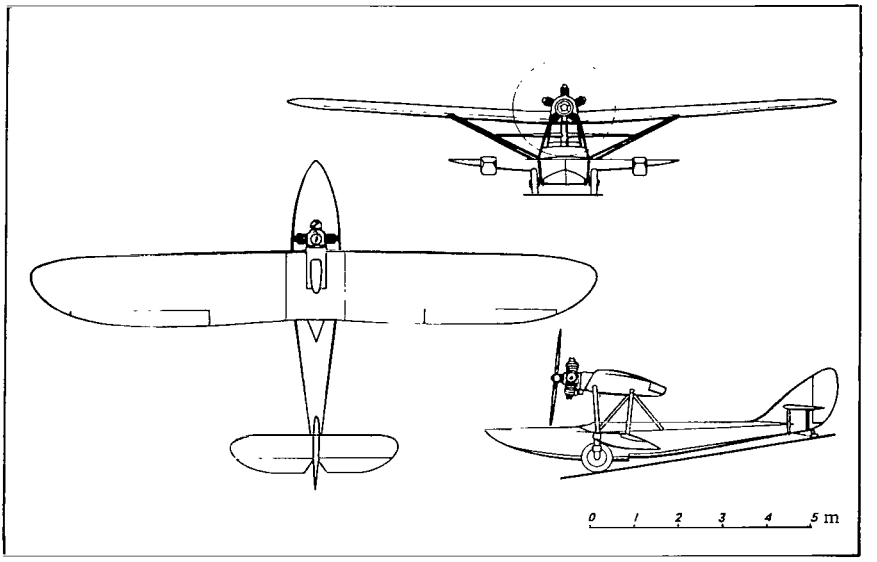
Trainer aircraft U-1 (Avro 540K), 1922.



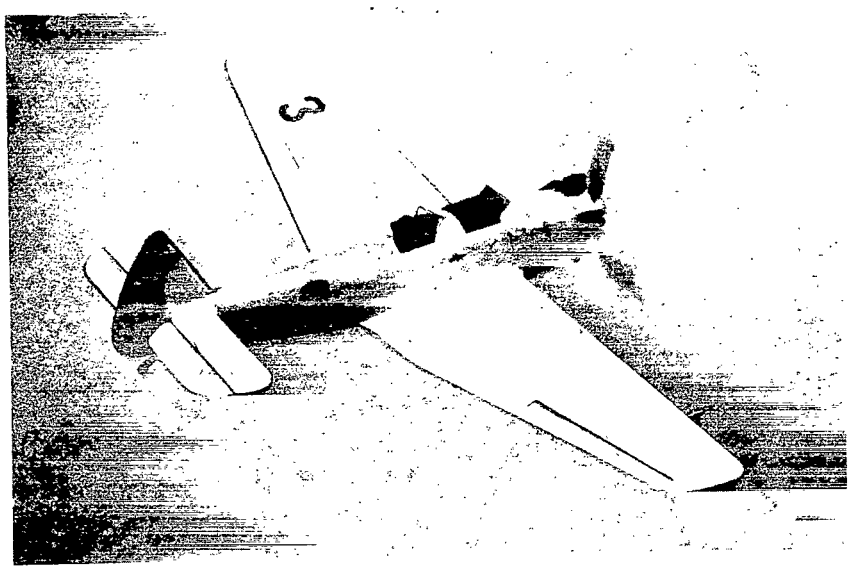


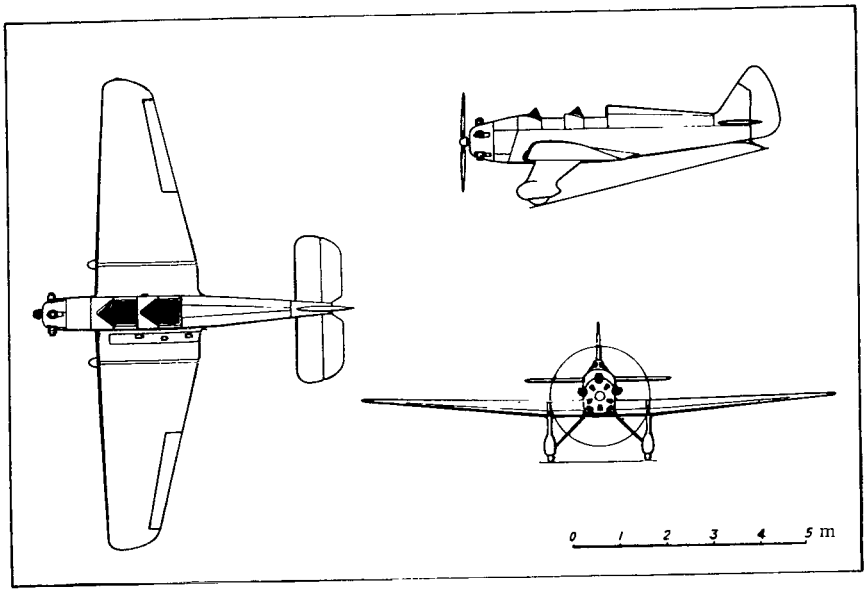
Trainer aircraft Po-2, 1927.



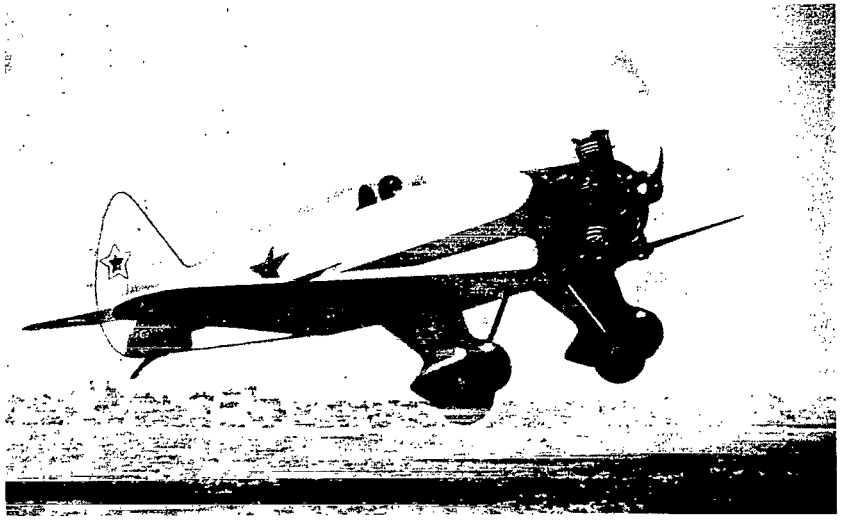


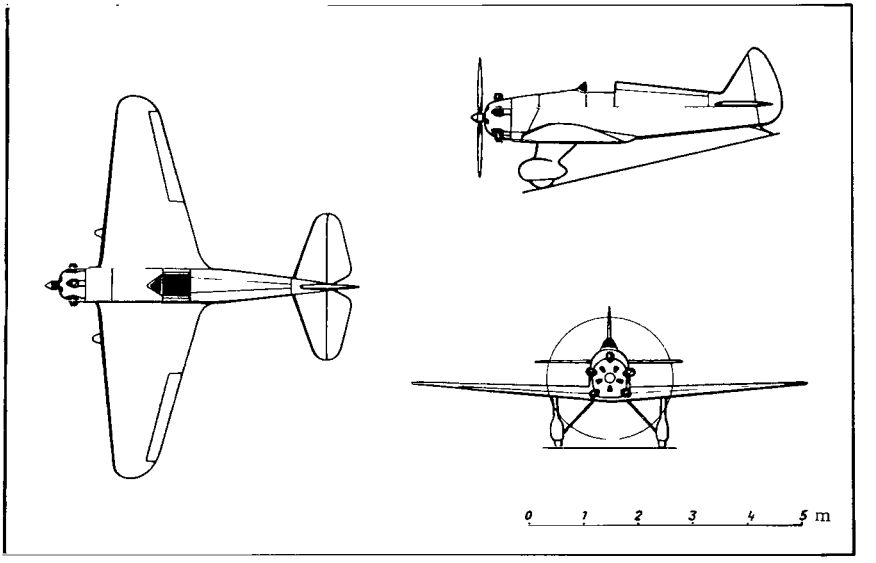
Amphibian trainer aircraft Sh-2, 1930.



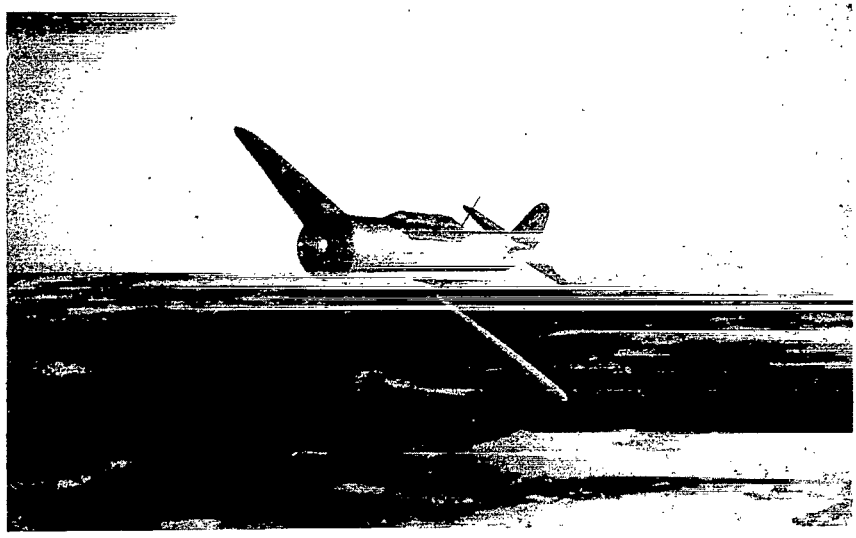


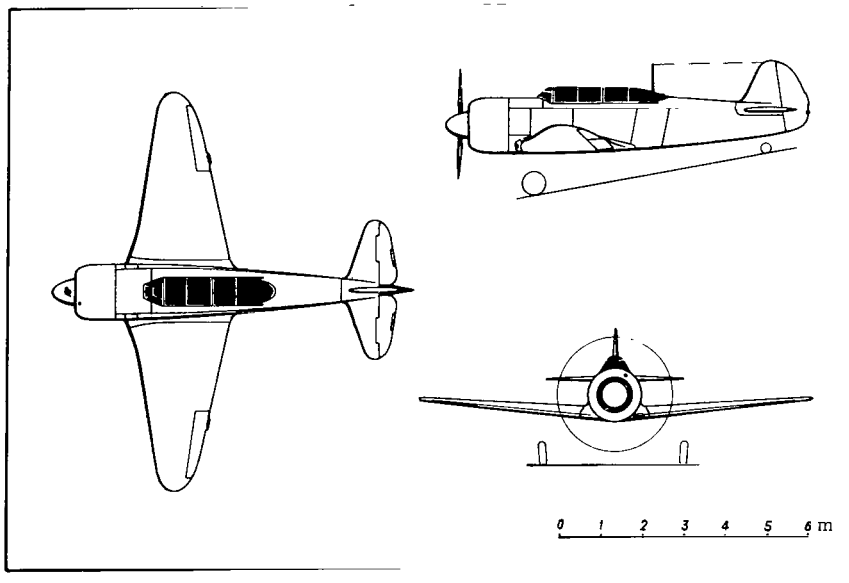
Trainer aircraft UT-2, 1935.



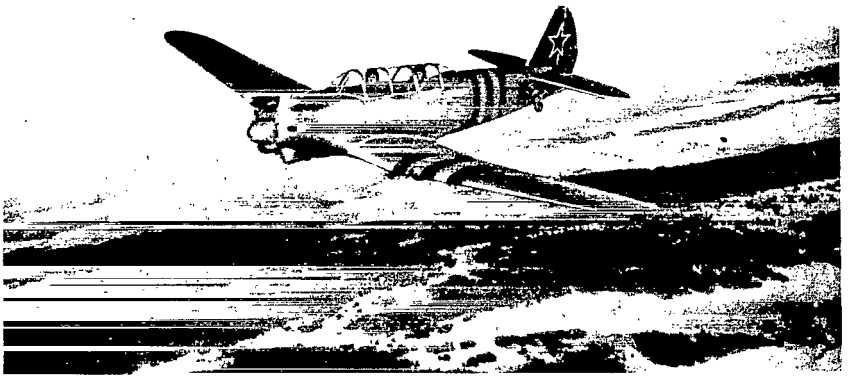


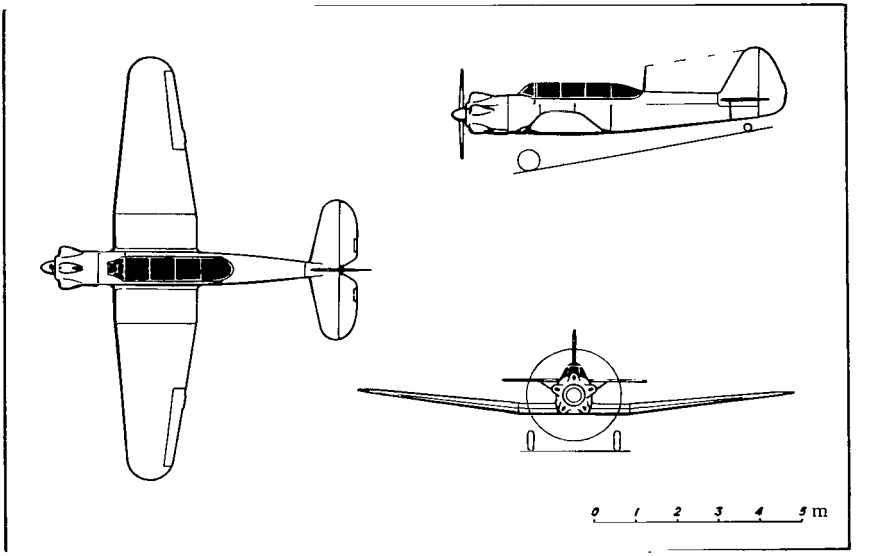
Trainer and sports aircraft UT-1, 1936.



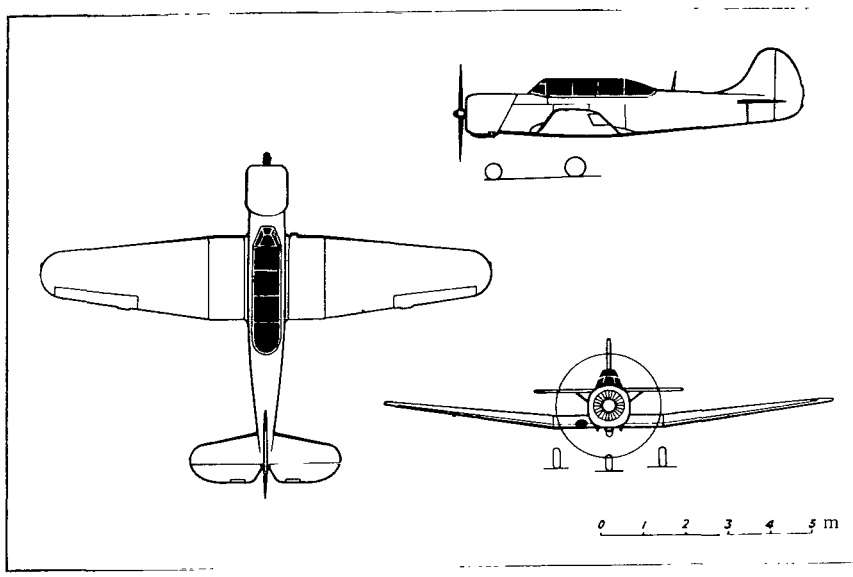


Trainer aircraft Yak-11, 1946.

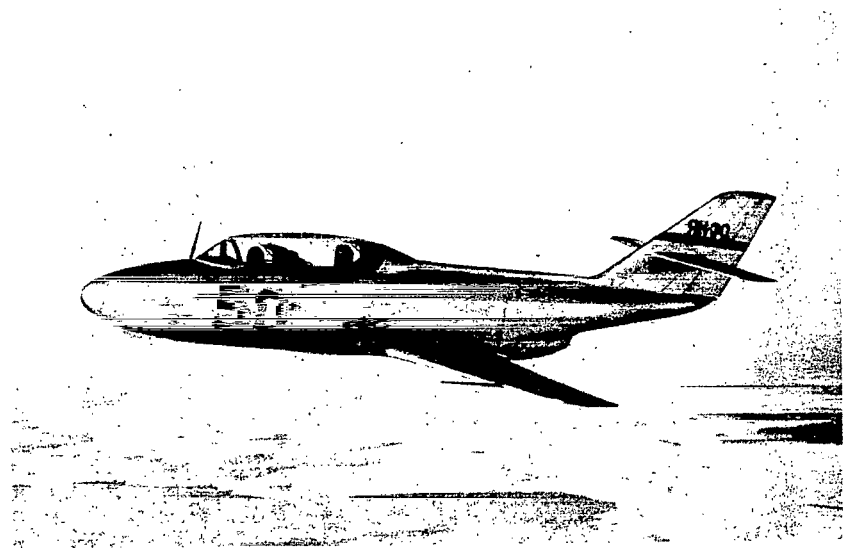


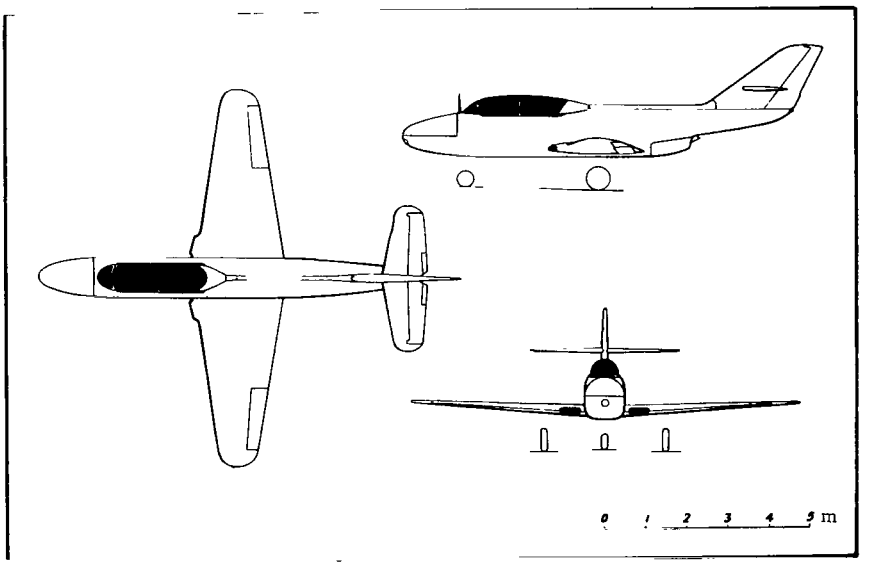


Trainer and sports aircraft Yak-18, 1946.

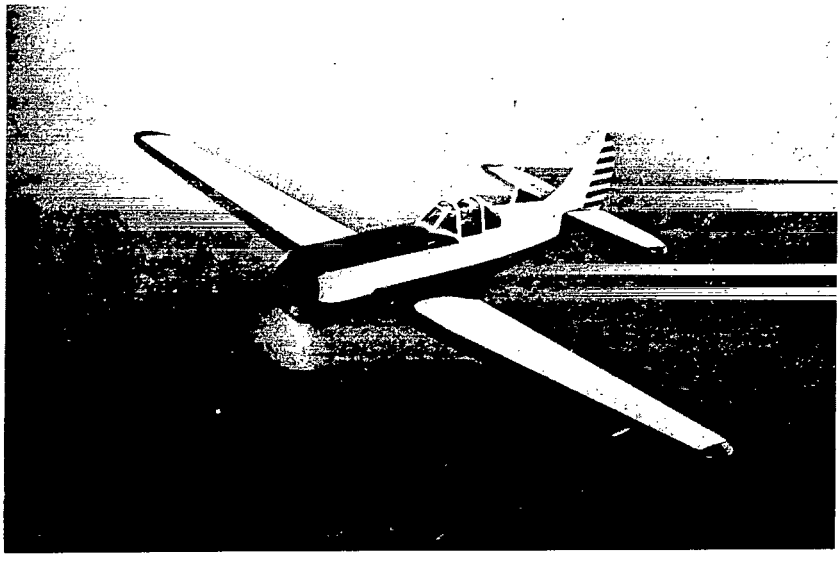


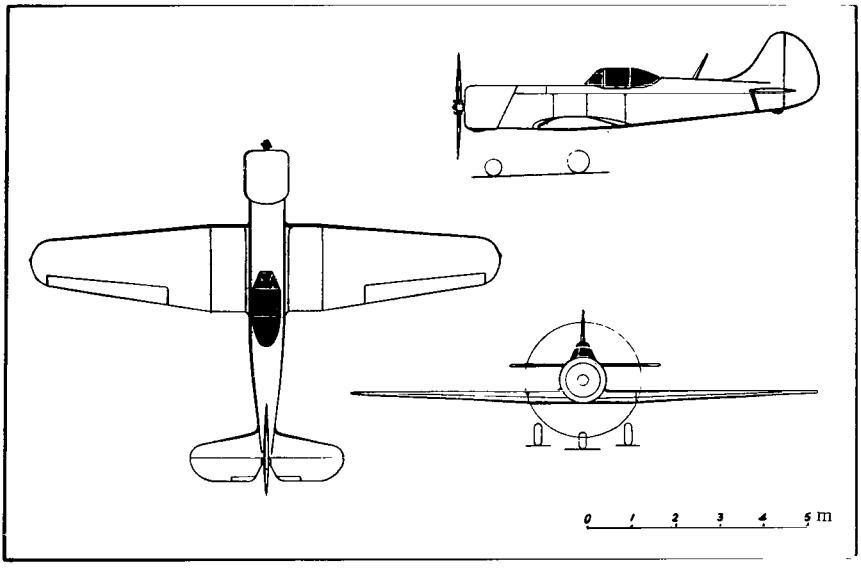
Trainer aircraft Yak-18A, 1957.





Trainer jet aircraft Yak-30, 1960.





Sports and aerobatics aircraft Yak-18PM, 1965.

9. *THE CIVIL AIR FLEET*

During the fifty years of Soviet power a great civil air fleet was created. Today air transport plays an important part in the economic life of the Soviet Union.

Recently the aircraft industry began large-scale production of jet passenger aircraft for different purposes, including transcontinental liners connecting Moscow with foreign countries. Modern planes for internal short and long air routes are also being produced.

Because of the length of airways and the volume of passenger and freight transport the Soviet company Aeroflot is definitely first among air lines.

Military and sports aviation were the first to attain high speeds and altitudes, but the civil air fleet has been equally successful.

Regarding air transport, prerevolutionary Russia did not leave any heritage at all. Not until Soviet power was established did a civil air fleet come into being, based on the greatly developed production of aircraft and engines. This civil air fleet has an important place among means of transport and affects the economic life of the USSR considerably.

Soviet civil aviation is relatively young. The first occasional air route from Moscow to Nizhni Novgorod, 420 km, was inaugurated in 1923. At that time the regular line Moscow—Königsberg was opened, provided with four-seater Fokker F-3 planes.

Soviet civil aviation expanded extensively and overcame many obstacles. As late as the middle thirties there were a few obsolete small Soviet-made K-5 and ANT-9 passenger planes and P-5 mail planes flying domestically. These planes were extremely inferior to the world standard of aviation technology. The industry, subordinated to the People's Commissariat of Heavy Industry, produced practically no civilian aircraft. Aeroflot (the former Main Administration of Civil Aviation (GUGVF)) had only small plants and research institutes and these could not provide a radical solution to the problems of air transport.

In 1930 A. I. Putilov designed a passenger plane, the Stal'-2; but by 1934 or 1935 it was already obsolete, though it was made of stainless steel, at that time the scarcest material in the Soviet Union. It was this alone that prevented further production or development of the plane. Production of engines for passenger planes was extremely backward.

In the mid-thirties the license for the production of the famous 24-seater passenger plane Douglas DC-3 was bought in the United States, and was then put into serial production in a Soviet aircraft factory. This had a certain effect on the development of civil aviation in the USSR. The plane received the designation Li-2 after B. P. Lisunov, the chief engineer who organized its serial production.

At that time the aviation public and the press criticized Aeroflot because civilian air transport was so backward. Aerodromes were also in a difficult

position. Even the Moscow airport, the central air terminal of the Soviet Union, was in an extremely bad state. Servicing of aircraft, workshops, internal transport of freight and luggage on the airport, the size of the airport — all this was deplorably inferior to other European airports.

It would seem surprising, but the perennial problem of passenger planes was solved at the peak of the war. Toward the end of 1943, when Soviet aviation had complete superiority, when the aircraft industry worked at full capacity and supplied the front with all the combat aircraft required, it was decided to start production of transport and passenger planes. This, of course, had to be done without jeopardizing combat aviation. An aircraft was required which would be able to fly faster and further than the Li-2, at that time the basic passenger plane.

In January 1944 the problem was discussed of a passenger express service able to transport ten to twelve passengers nonstop over a distance of 4000 km or 5000 km. Also considered was the possibility of adapting some existing bomber for this purpose, e.g., the Er-2 bomber designed by V. G. Ermolaev, which was powered by diesel engines. However, doubts were raised whether it would be possible without radically changing the fuselage to place twelve passengers in the plane and ensure a minimum of comfort required for flights lasting 10 or 15 hours.

At that time Ilyushin was working on a twin-engined transport and passenger plane Il-12 whose prototype with diesel engines was being built. In this context, it seemed inopportune to change the Er-2 into a passenger plane.

Soon the Il-12 was mass-produced but not with diesel engines. Instead it was powered by two air-cooled ASh-82 engines. In 1947 the Il-12 planes, powered by two piston engines, were in abundance on the civil airways of the USSR. They were later modified and designated Il-14, which was the classical monoplane with two air-cooled wing-mounted engines. For their time these planes were excellent, economical and safe.

Immediately after the Il-12 and Il-14, Ilyushin's design office began work on a large passenger plane, the Il-18, powered by four piston engines.

However, this first version of the Il-18 was not mass-produced. It was thought that such large planes would not be needed.

It soon became apparent that Soviet civil aviation was beginning to lag seriously behind the West, where jet-powered multiseat passenger planes appeared.

The first commercially operated passenger jet aircraft in foreign airlines was the British four-engined, sixty-seat Comet produced by De Havilland. The Comet went into operation in the early fifties. After three crashes within its first year, the plane had to have its reliability fought for by the company. After the shortcomings had been remedied, the Comet was again put into production, and now for more than fifteen years it has been flying on many airways all over the globe.

The problem of building a passenger jet plane was solved by adapting the series-produced military aircraft Tu-16 designed by Tupolev and powered by two AM-3 engines of 8 tons thrust each designed by Mikulin; this plane had been thoroughly tested in military practice. The adaptation concerned the fuselage, or rather a new fuselage was produced, originally for fifty passengers ensuring the necessary comfort.

Regardless of the difficulties of changing over from bomber to passenger plane, the Tu-104 was successful, especially economically and in take-off

and landing characteristics. Its favorable qualities became even more apparent after the number of passengers had been raised to one hundred. For several years, beginning in 1956, the Tu-104 was the basic aircraft type on trunk lines of the civil aviation. Its cruising speed exceeds 800 kph, its range is 3100 km.

The Tu-104 was a great achievement of Soviet aircraft construction, both for prestige and as a pioneering venture, blazing the trail for widespread use of jet passenger planes on the major airways of the country.

The problem of supplying civil aviation with modern passenger planes was disucssed by the Central Committee of the Party. The designers Tupolev, Ilyushin, Antonov, and the leading executives of the aircraft industry were instructed to explore the possibilities of building passenger planes corresponding to contemporary requirements and the international standing of the Soviet Union.

In 1954 Tupolev, Ilyushin, and Antonov received concrete assignments to build new passenger planes which could compete with Western models.

A short time later Il-18, An-10, and An-24 planes appeared on test airfields, as did the largest airliner in the world, the Tu-114. All these planes underwent comprehensive tests, were then put into serial production and went into operation on the airways of civil aviation. A characteristic peculiarity of all the Soviet passenger planes, except the Tu-104, which had turbojet engines, was that they were turboprop planes which are more economical as to fuel consumption.

Tupolev's second jet liner, the Tu-114, was designed for one hundred seventy passengers. Its range was greater than that of any other passenger plane. The plane, powered by four turboprop engines, has a speed of about 900 kph. The Tu-114 takes 11 or 12 hours flying time from Moscow to New York.

In recent years Antonov's planes have occupied an important place in the civil air fleet. From among his planes the one hundred-seat transport and passenger plane An-10 should be mentioned. With its four turboprop engines of 4000 hp each, it has a cruising speed of 630 kph. Its maximum range is 4000 km. Immediately after this followed the An-24, a fifty-seat passenger plane with two turboprop engines of 2500 hp each, and then came the An-22, which was successfully shown at the Paris air salon in 1965. With its four turboprop engines of 15,000 hp each, it was the largest aircraft in the world at that time.

In the forties Antonov designed a multipurpose light single-engine biplane, the An-2, which found recognition and widespread use both in the USSR and abroad. The An-2 with an ASh-62M piston engine of 1000 hp has been used for many years in the most diverse branches of the economy. It is a dependable and indispensable aircraft, both in agriculture and on local passenger lines. The An-2, together with Polikarpov's excellent Po-2 is one of the most long-lived Soviet aircraft. Such planes are ageless.

In the late fifties civil aviation operated three main passenger liners, the Tu-104, An-10, Il-18, and the transcontinental Tu-114.

Of the first three planes the Il-18 was the most economical. It had the longest range, the best take-off and landing characteristics and was least susceptible to weather conditions, because it was specially planned as a passenger plane with all the features necessary for a passenger plane. It became the main passenger plane under the Ministry of Civil Aviation.

The Il-18V had four turboprop AI-20 engines of 4000 hp each. The Il-18 flies at 8000 m with a cruising speed of 650 kph. Its range is 5000 km. It

has very good take-off and landing characteristics. The take-off run, depending on the load, is 750 m to 900 m, the landing run is only 550 m.

To this day the Il-18 is series-produced, both for domestic use and for export. However, the 111-seat Il-18 is a main-line plane, and the country feels a shortage of planes for local lines, for which An-24 and Tu-124 planes were ordered. These planes are in serial production, and since the early sixties they have been supplied to Aeroflot.

The Tu-124 with two 5-ton D-20P engines is in overall shape and aerodynamic configuration similar to the Tu-104, only scaled down. It was radically modified and provided with two D-30 jet engines of 6800 kg thrust each, mounted outside the tail part of the fuselage. The number of seats in the passenger compartment was increased to seventy-two. Thus a new passenger plane appeared, the Tu-134, which was immediately series-produced.

It is intended for passenger flights over medium distances, i.e., 1500 km to 2000 km. Its cruising speed is 870 kph. Soon after the aerial display in Domodedovo, these aircraft started on regular passenger service.

Finally, in 1967, the 186-seat gigantic, new transcontinental Il-62 passenger planes went into service. They are powered by four NK-8 jet engines of 10.5 tons thrust each. This plane was a worthy successor to the turboprop veteran Tu-114 which had been flying domestically and internationally for Aeroflot.

The Il-62 was the object of general attention at the Aviation Salons in Paris in 1965 and 1967, where it was exhibited together with other Soviet aircraft. No less successful was another exhibit, a model of the supersonic passenger liner Tu-144 shown in the Soviet space pavilion.

In 1967 the Yak-40 underwent flight tests. This was a three-engined jet for local flights, especially designed for operating from unpaved small airfields. In the USSR as in other countries most passengers on local lines fly in obsolete slow piston-engined planes which should have been replaced long ago.

Many aircraft manufacturers in the world are examining the problem of designing a high-speed jet aircraft suitable for operating from unpaved small airfields. How urgent the need for such an aircraft has become is illustrated by a curious fact. In the mid-sixties a special competition was held in the United States for the best aircraft of local airlines. The conditions were the following: the aircraft must be suitable for runways not more than 800 m long, carry fourteen to thirty passengers, be economical, have a cruising speed of 370 kph and a range of 1100 km.

The competition was held because in the United States local lines operate such obsolete planes as the Douglas, Convair-240, Martin-202 and so forth. It was intended by 1970 to replace these old, worn out, piston-engined planes by the winning plane of the competition. However, things were not that easy. Out of the nine designs submitted in the competition, not one was approved.

Regarding the number of passengers, payload and range, the Yak-40 belongs to the same class as the Il-12, Il-14, and Li-2, but its cruising speed (550—600 kph) is twice as great as the cruising speed of its predecessors, and the passenger compartment of the Yak-40 provides all the requirements of modern comfort. The Yak-40 replaces the former planes on short air routes between 600 km and 1500 km long.

The power plant of the Yak-40 consists of three AI-25 jet engines located in the rear section of the aircraft. Two engines are located on the sides, the third one is inside the fuselage. In the tail of the aircraft there is a small auxiliary gas turbine runner for starting up the main engines.

The AI-25 was designed by the office headed by the Hero of Socialist Labor A. G. Ivchenko. It is a light and economical turbofan engine.

Thus Aeroflot received in 1967 a whole family of new planes: the 24-seat Yak-40 for short runs, the 72-seat Tu-134 for medium lines and the 182-seat intercontinental Il-62. The take-off weights of these planes are 13, 44, and 150 tons, respectively.

The largest aircraft in the world, the giant An-22, is already well known in the Soviet Union and abroad. The An-22 was twice exhibited at the Paris Air Salon and aroused the visitors' attention by its extraordinary size. The cargo space of the plane is so large that it can easily accommodate buses.

The An-22 is powered by four turboprop engines of 15,000 hp each. It has an enormous lifting capacity, as attested to by the records established on 26 October 1967. On that day the crew, headed by the distinguished test-pilot I. Davydov, attained an altitude of 7800 m with more than 100 tons payload on board. In one flight fifteen world records were established for lifting to such an altitude a load of 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, and 100 tons. Further, the previous records for lifting capacity were also achieved by an An-22 plane, in October 1966.

Thanks to the excellent technical equipment and the high skill of the flying personnel, Aeroflot became the largest airline in the world. The total length of the airways of Soviet civil aviation is about 500,000 km. Air transport serves more than 3000 towns and large settlements in the USSR. The lines Moscow—Yuzhno—Sakhalinsk, Leningrad—Yuzhno—Sakhalinsk, Petropavlovsk—Kamchatskii—Simferopol are the longest continental air routes in the world. On some days Soviet air liners transport 150,000 to 200,000 passengers. In 1967 more than 55 million passengers were transported. Aeroflot provides one-third of all the passenger transport in the world.

Soviet aircraft fly in fifty foreign countries. The foreign routes add up to approximately 100,000 km. Aeroflot's leading air liner, the Tu-114, flies on passenger runs from Moscow—Havana and Moscow—New Delhi. More than thirty foreign countries placed orders for Soviet aircraft Tu-104, Il-18, and Il-14.

The Soviet Five-Year Plan of Economic Development for the years 1966—1970 envisaged a considerable development of civil aviation. The guidelines approved by the 23rd Congress of the Party state: "To increase by about 1.8 times the air transport of passengers (by planes and helicopters). To build thirty-five to forty main-line airports and two hundred airports for local lines. To provide main-line airports of national importance with automatic or semiautomatic approach control and with modern radio equipment for traffic control."*

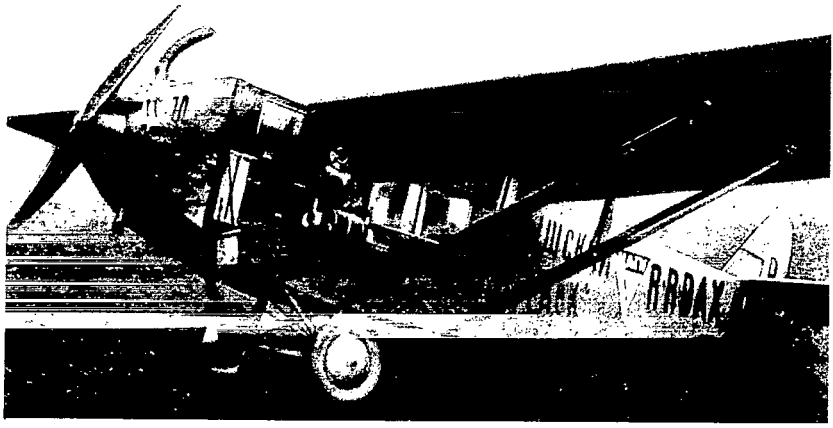
In the present Five-Year Plan the design offices will continue work on new and improved aircraft. It is in the immediate future that Soviet passenger aircraft, like military aircraft, will fly at supersonic speeds. Then a flight from the USSR to America across the ocean or to India over high mountains will take no more than 3 or 4 hours.

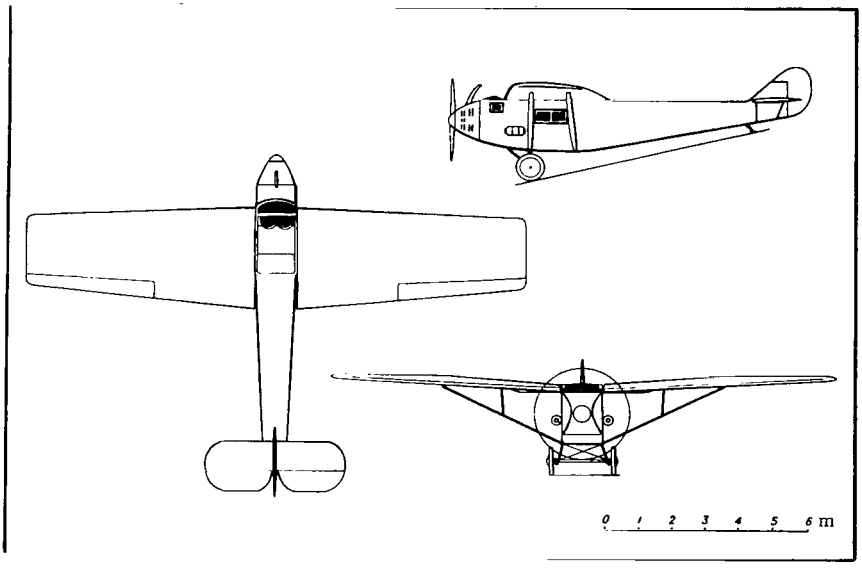
The Soviet aircraft industry, basing itself on new achievements of science and technology, reliably ensures increasing power to the military air force and continuous improvement of the civil air fleet.

* Materialy XXIII s"ezda KPSS (Documents of the 23rd Congress of the CPSU), p. 254. — Moskva, Politizdat. 1966.

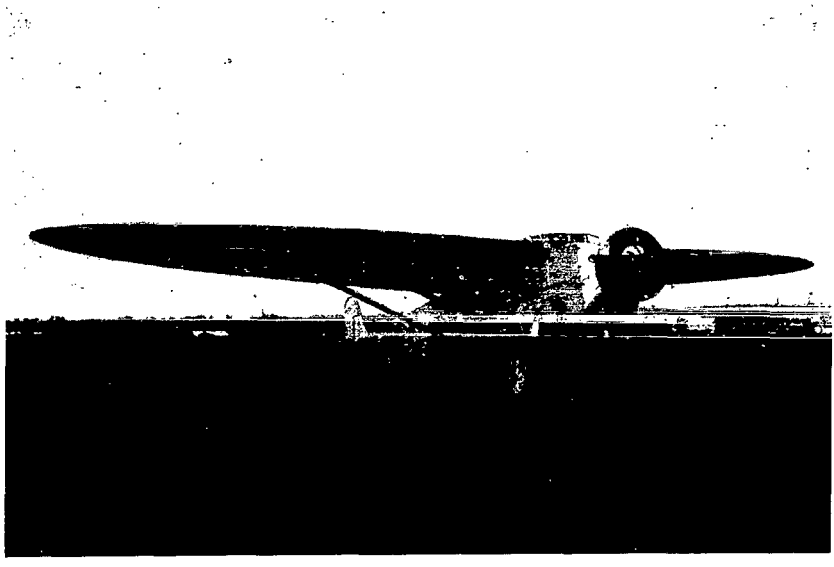
Passenger aircraft

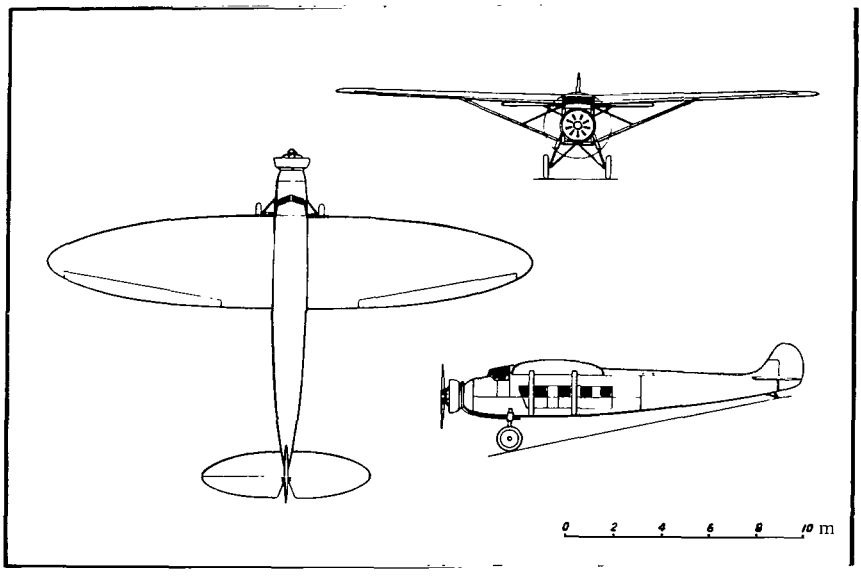
Type of aircraft	Year of production	Engines (type, number, power or thrust)	Take-off weight, kg	Maximum payload		Crew	Cruising speed, kph	Range, km	
				number of passengers	kg			with maximum payload	maximum (with load)
AK-1	1924	Salmson, 170 hp	1670	3	225	1	130	450	—
K-5	1929	M-17, 500 hp	4000	6	540	2	172	1020	—
ANT-9	1929	Titan, 3 × 230 hp	5044	9	810	2	170	830	—
		M-17, 2 × 500 hp	6200				222		
Maxim Gorki	1934	M-34FRN, 8 × 840 hp	42,000	80	14,444	8	200	2000	—
Li-2	1938	ASh-62IR, 2 × 1000 hp	10,700	24	2200	4	220	120	2000 (250 kg)
Il-12	1946	ASh-82FN, 2 × 1850 hp	17,250	32	3500	4	300	300	1900 (1830 kg)
Il-14M	1950	ASh-82T, 2 × 1900 hp	17,500	36	3300	4	320	400	1750 (1600 kg)
Tu-104B	1955	RD-3M, 2 × 9700 kg	76,000	100	12,000	5	800	2100	3100 (6350 kg)
Il-18D	1957	AI-20M, 4 × 4250 eff. hp	64,000	122	13,500	5	650	3700	6500 (9000 kg)
An-10A	1957	AI-20K, 4 × 4000 eff. hp	54,000	100	15,000	5	630	1200	4000 (3000 kg)
Tu-114	1957	NK-12MB, 4 × 15,000 eff. hp	171,000	170	30,000	5	770	6200	8950 (15,000 kg)
An-24	1959	AI-24, 2 × 2550 eff. hp	21,000	50	5500	3	450	650	2000 (3400 kg)
Tu-124	1960	D-20P, 2 × 5400 kg	36,500	56	6000	3	800	1250	2100 (3500 kg)
Il-62	1963	NK-8, 4 × 10,500 kg	157,500	186	23,000	5	850	6700	9200 (10,000 kg)
Tu-134	1964	D-30, 2 × 6800 kg	44,000	72	7100	3	870	2400	3250 (5000 kg)
Yak-40	1967	AI-25, 3 × 1500 kg	13,350	24	2500	2	600	600	1500 (1500 kg)



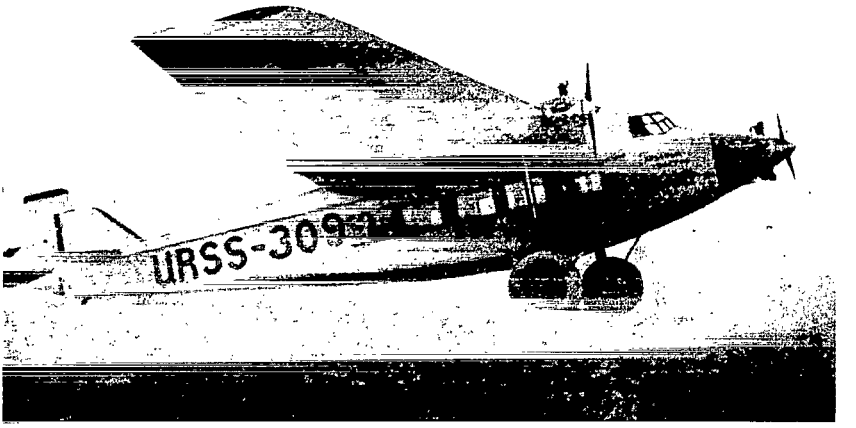


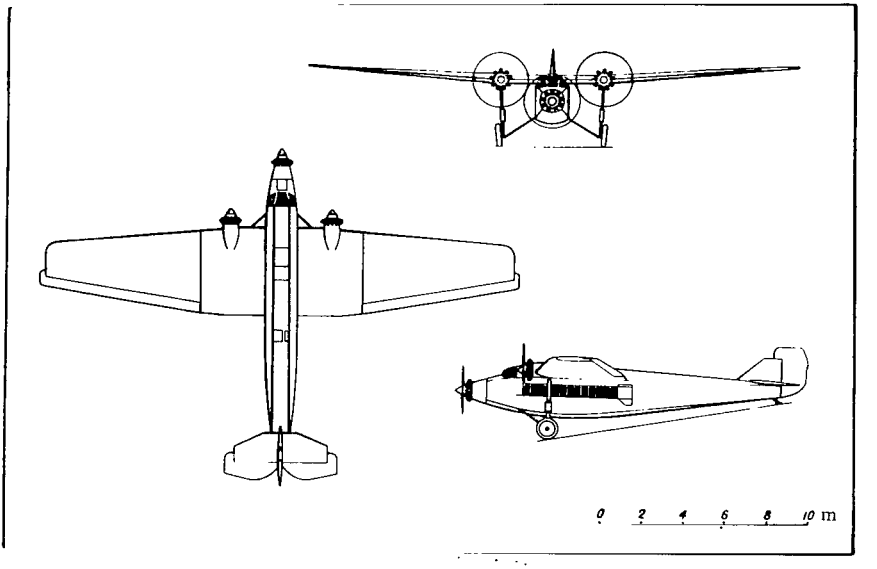
Passenger aircraft AK-1, 1924.



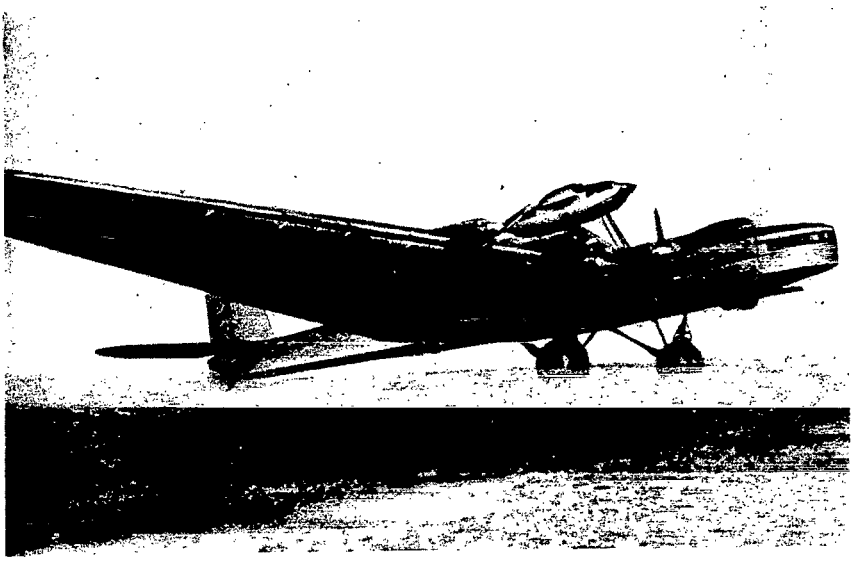


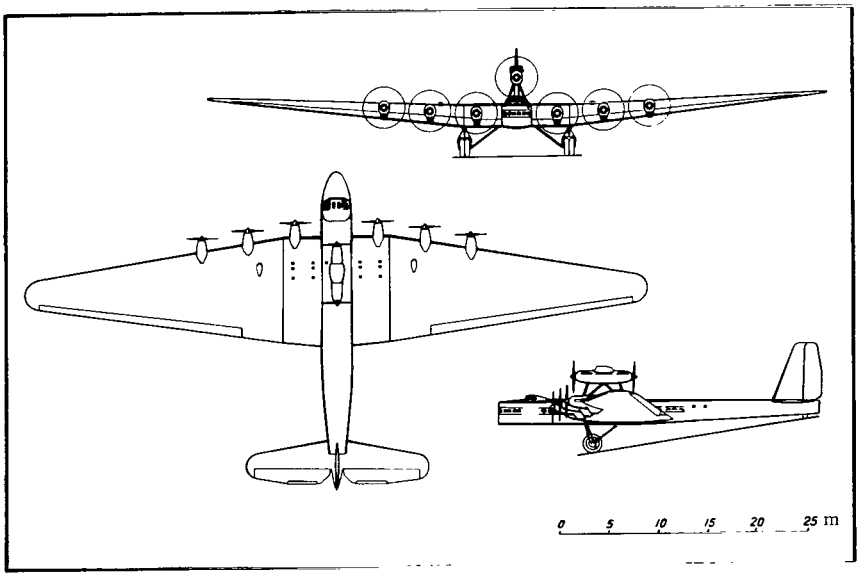
Passenger aircraft K-5, 1929.



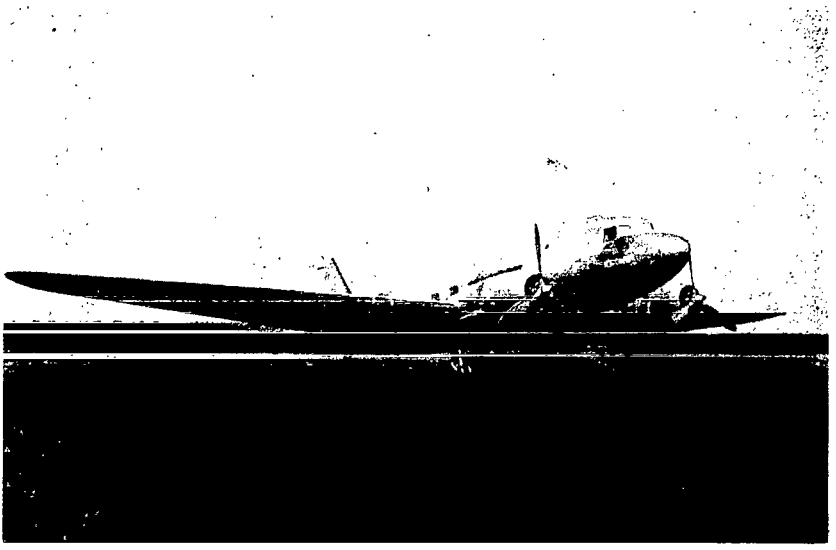


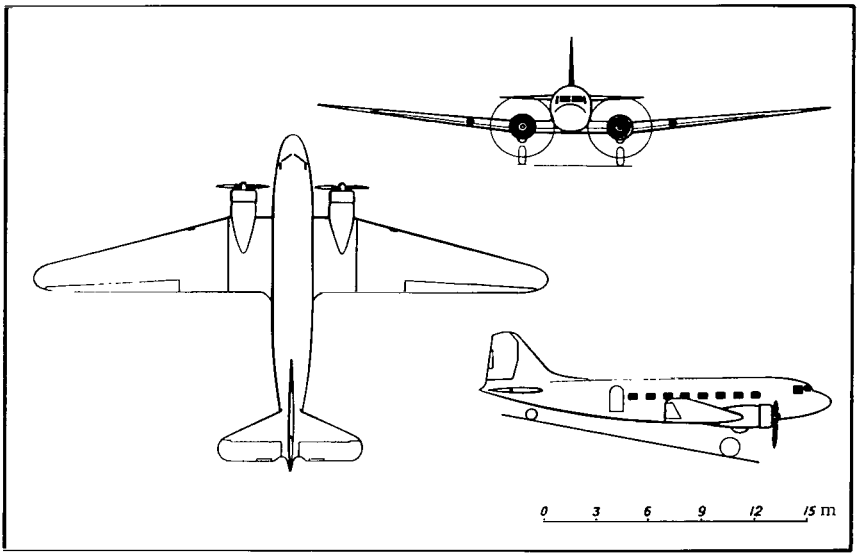
Passenger aircraft ANT-9, 1929.



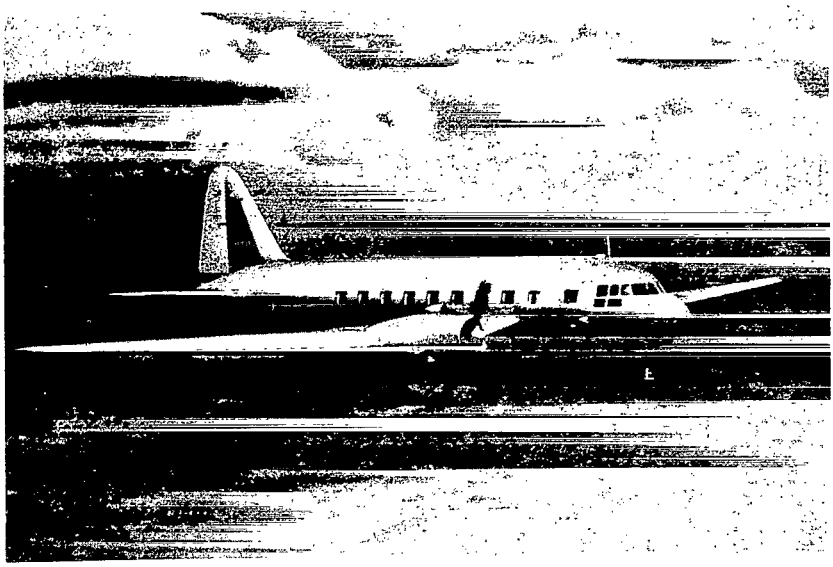


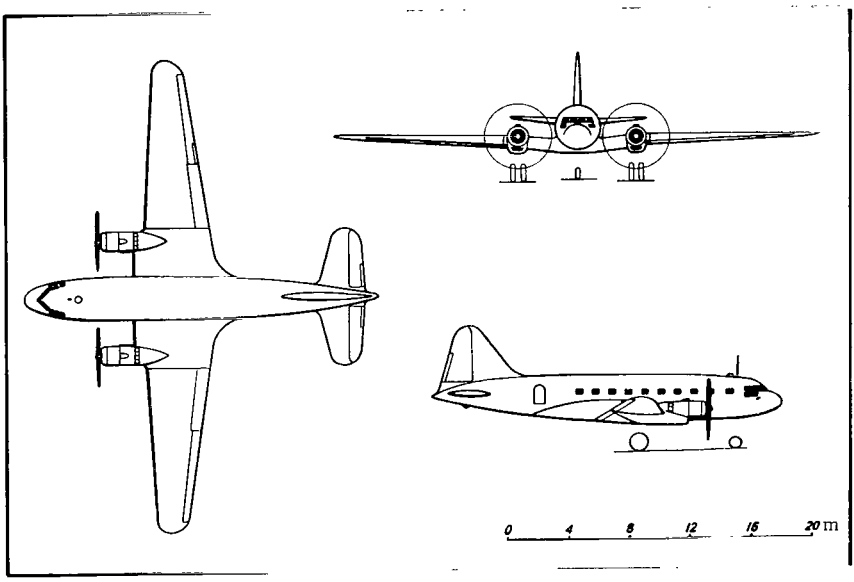
Propaganda aircraft "Maxim Gorki," 1934.



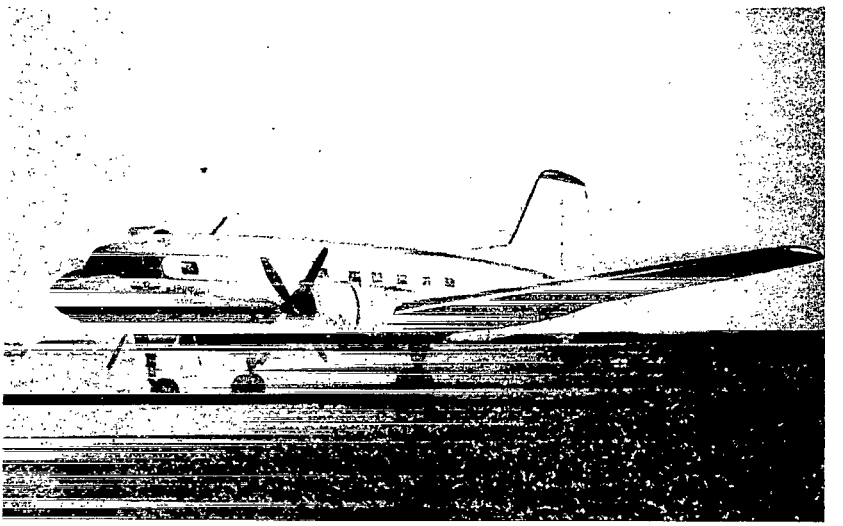


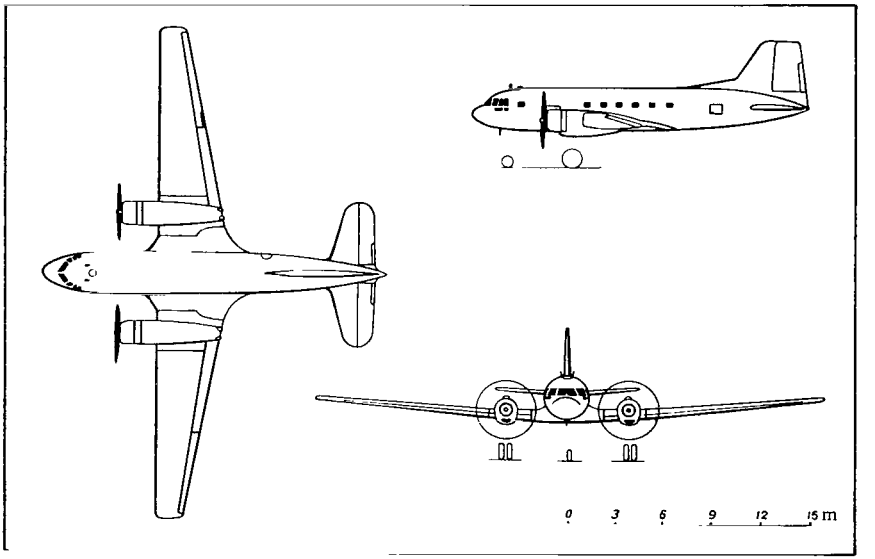
Passenger aircraft Li-2, 1938.



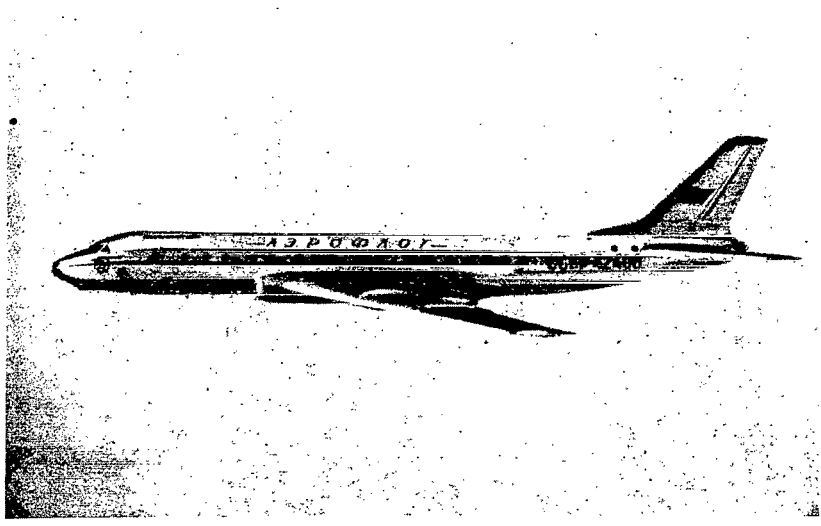


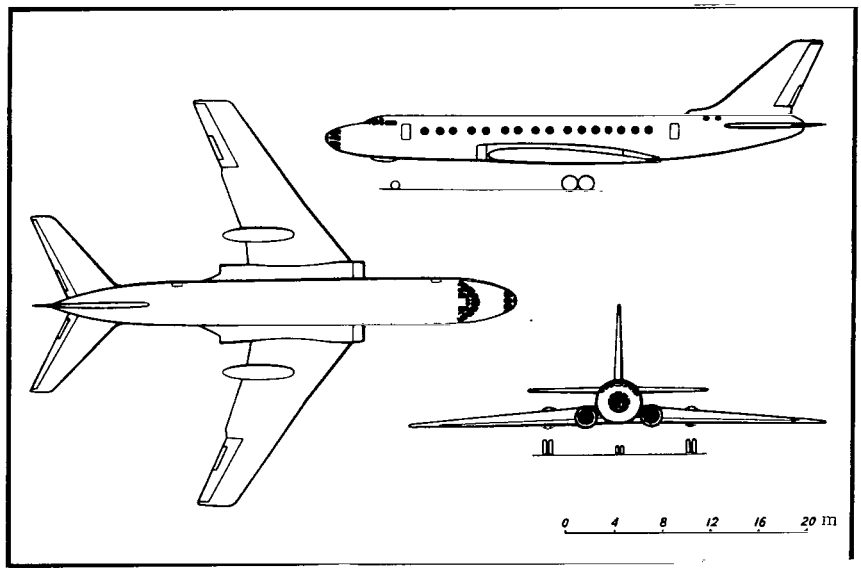
Passenger aircraft Il-12, 1946.



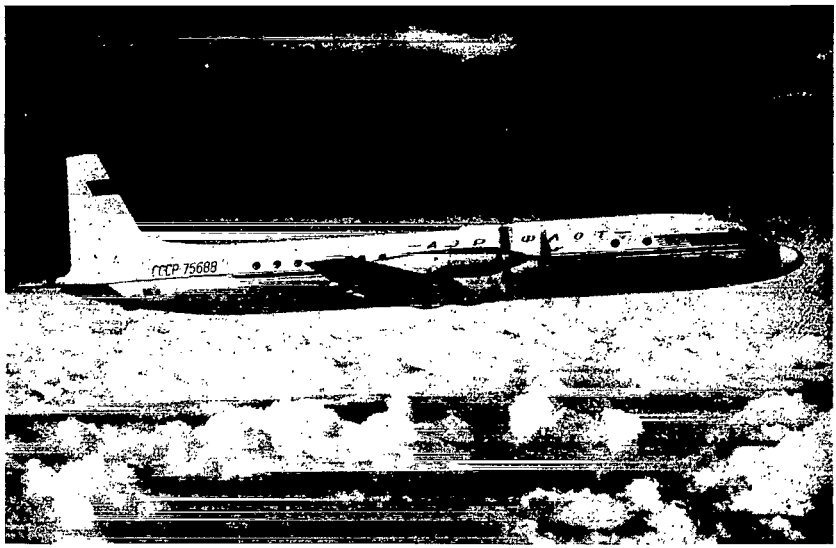


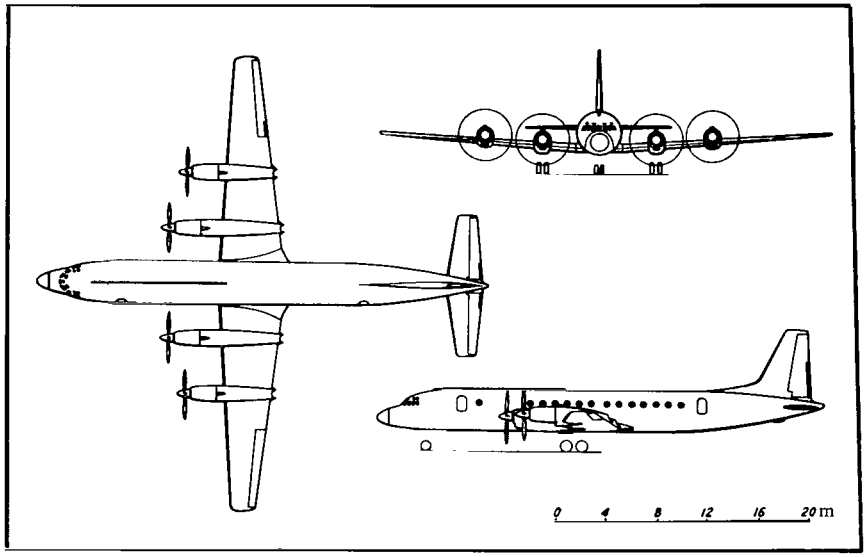
Passenger aircraft Il-14, 1950.



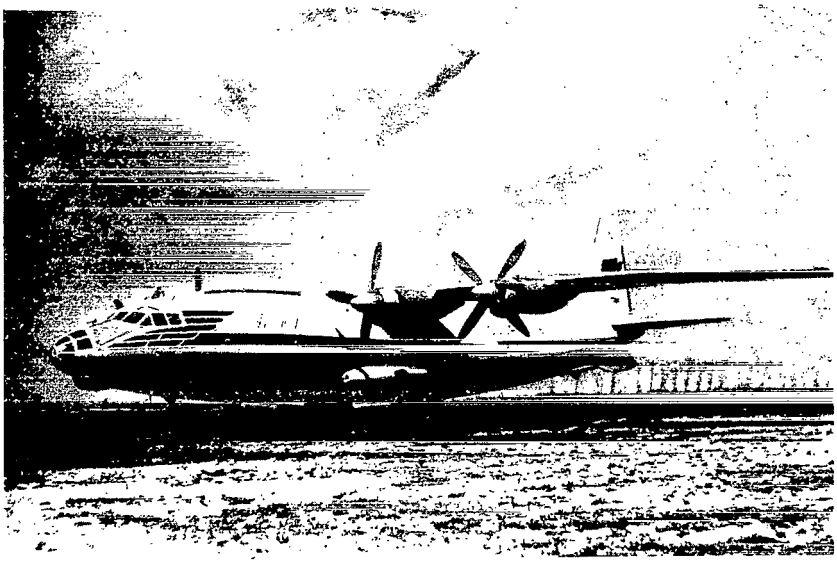


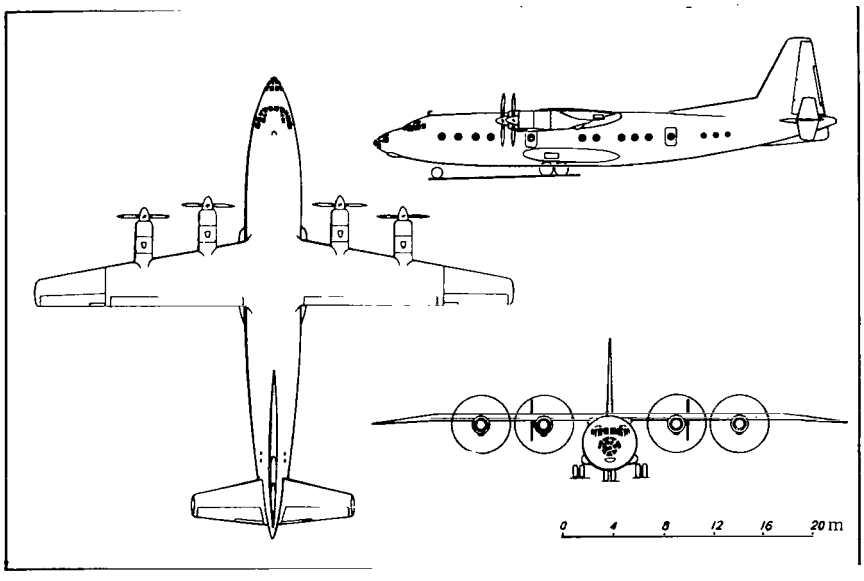
Passenger aircraft Tu-104, 1955.



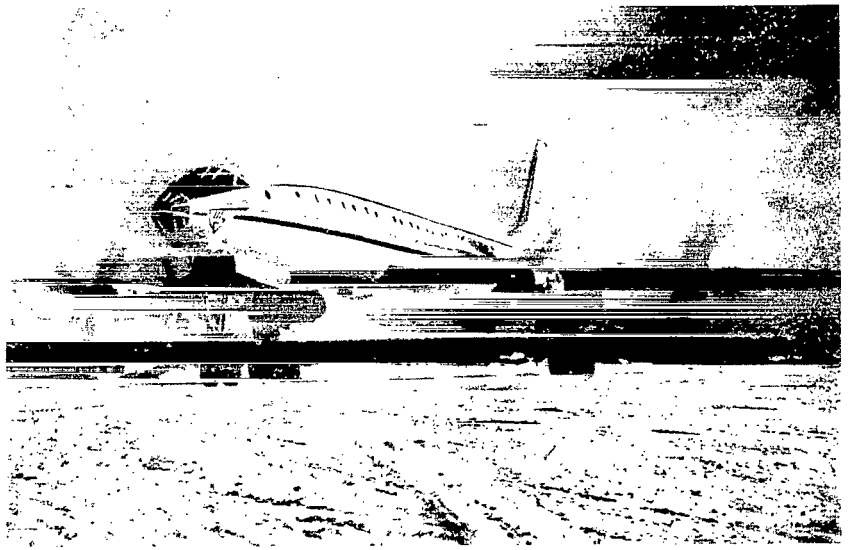


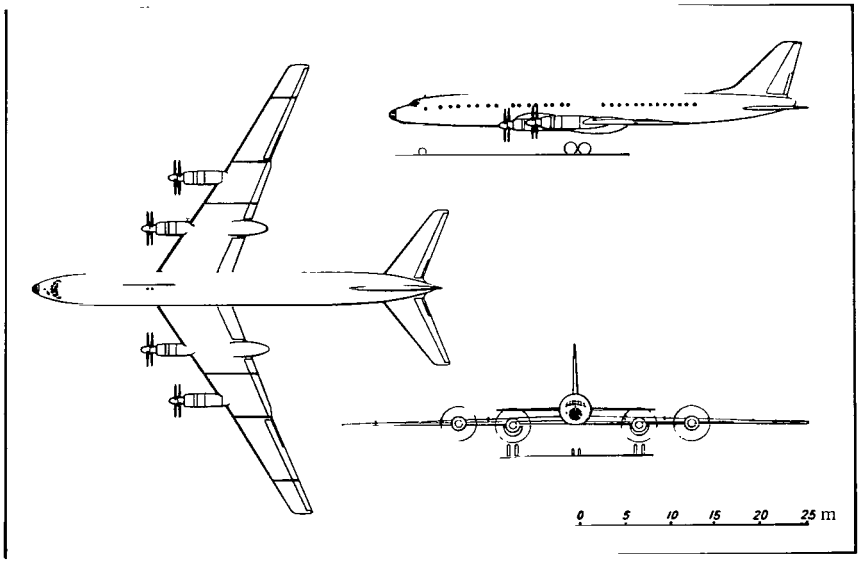
Passenger aircraft Il-18, 1957.



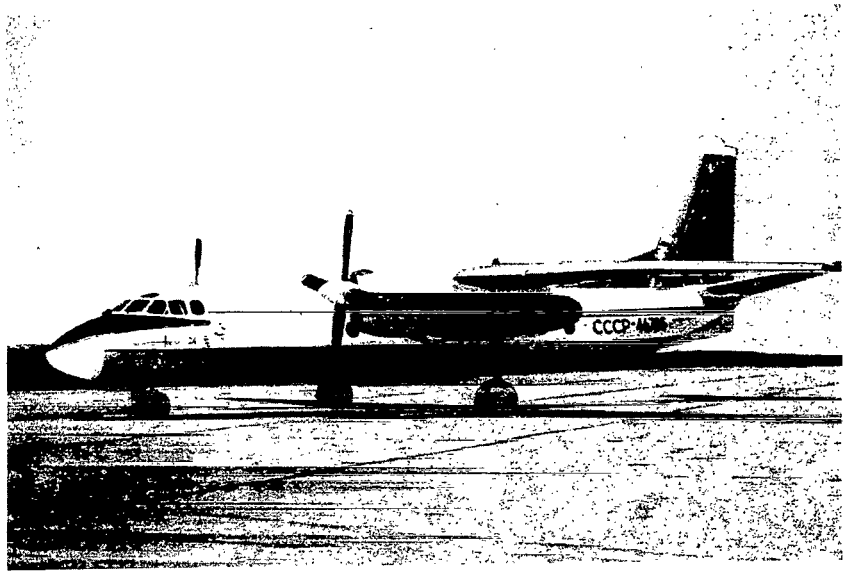


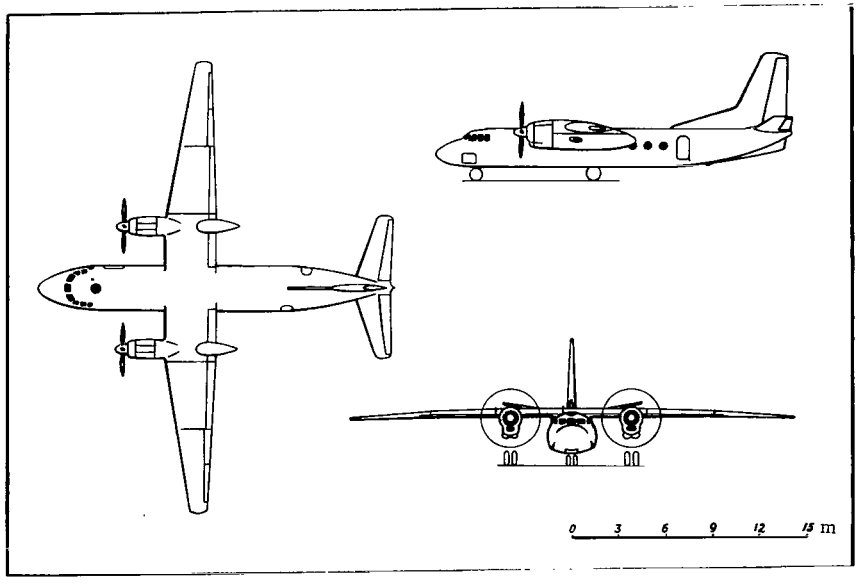
Passenger aircraft An-10, 1957.



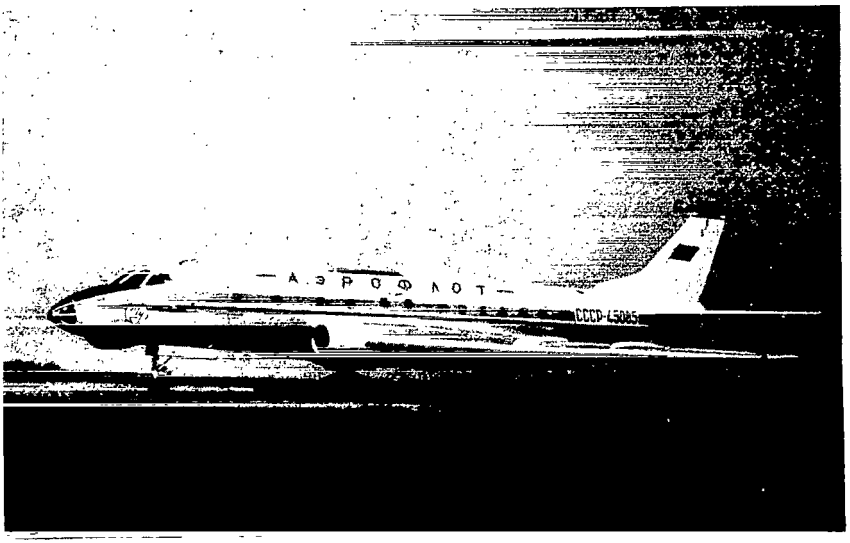


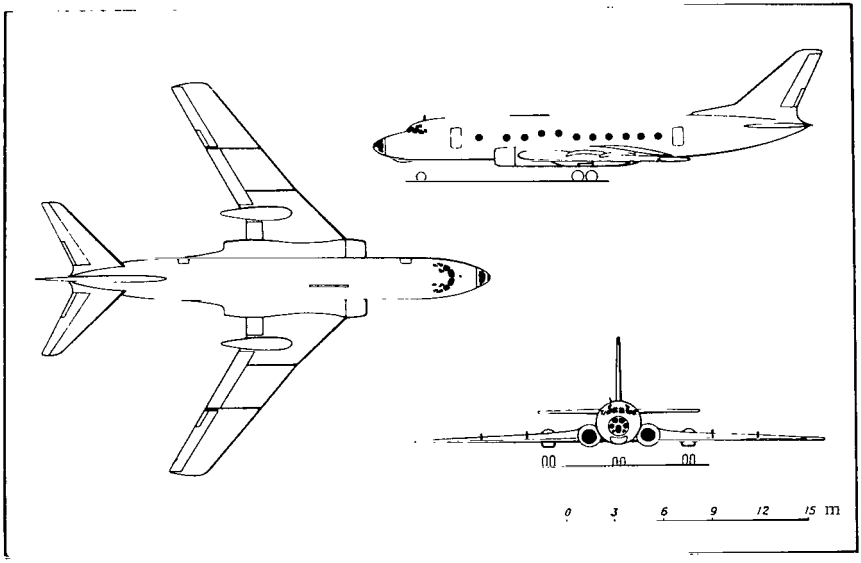
Passenger aircraft Tu-114, 1957.



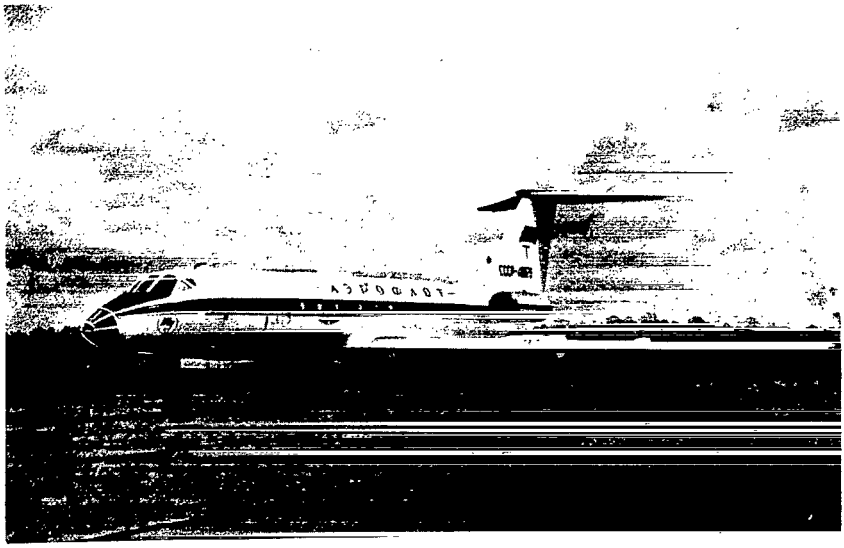


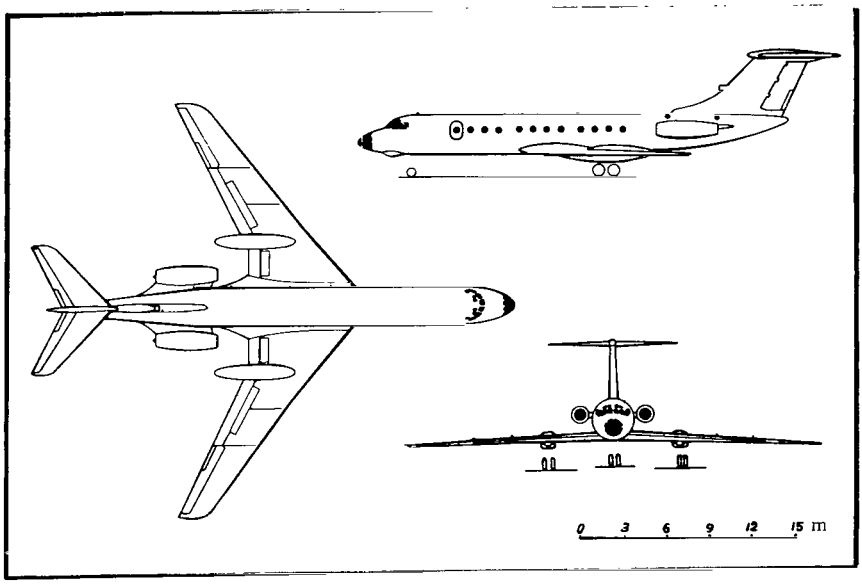
Passenger aircraft An-24, 1959.



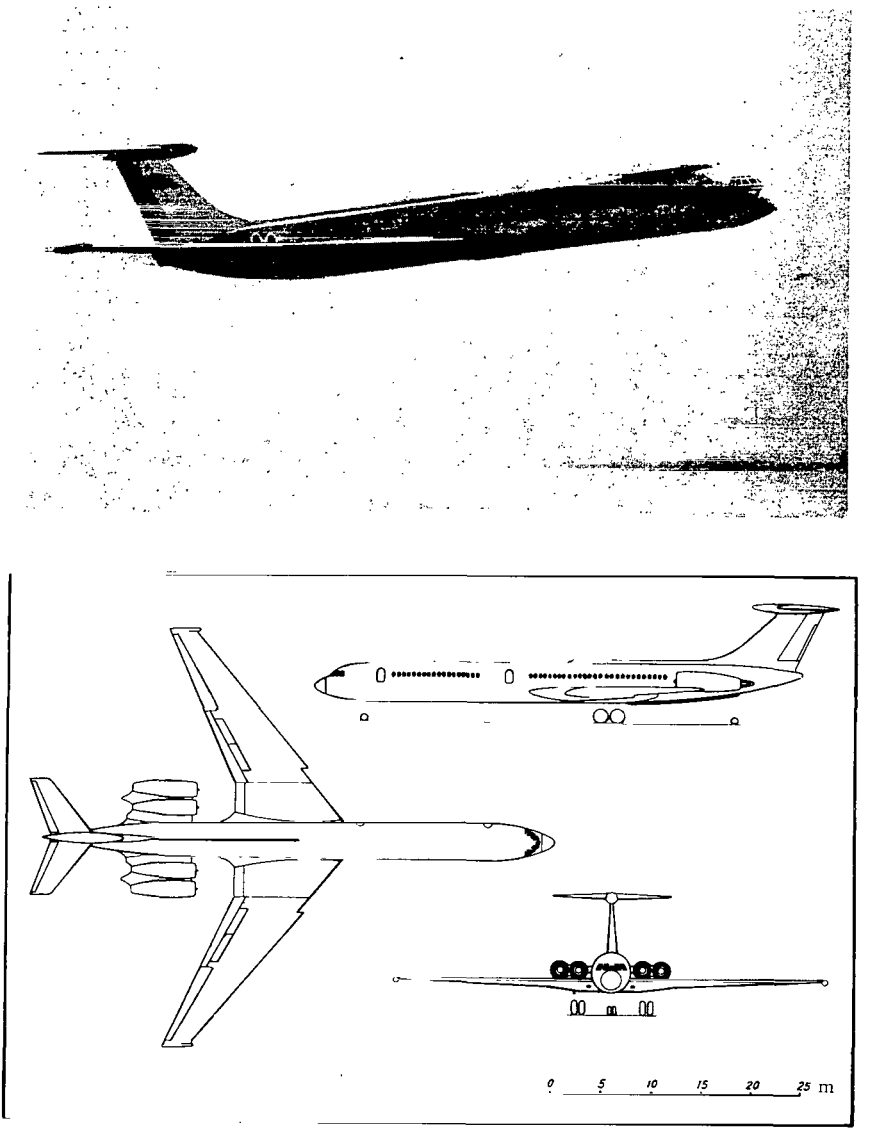


Passenger aircraft Tu-124, 1960.

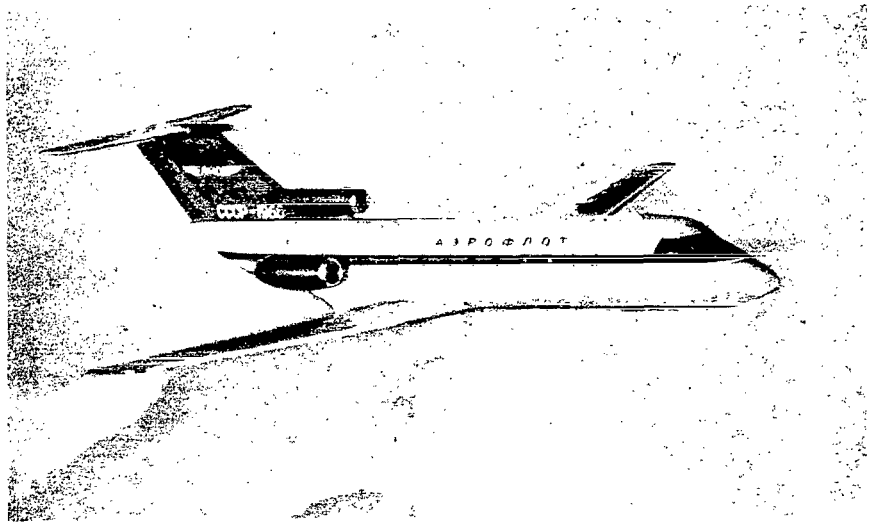


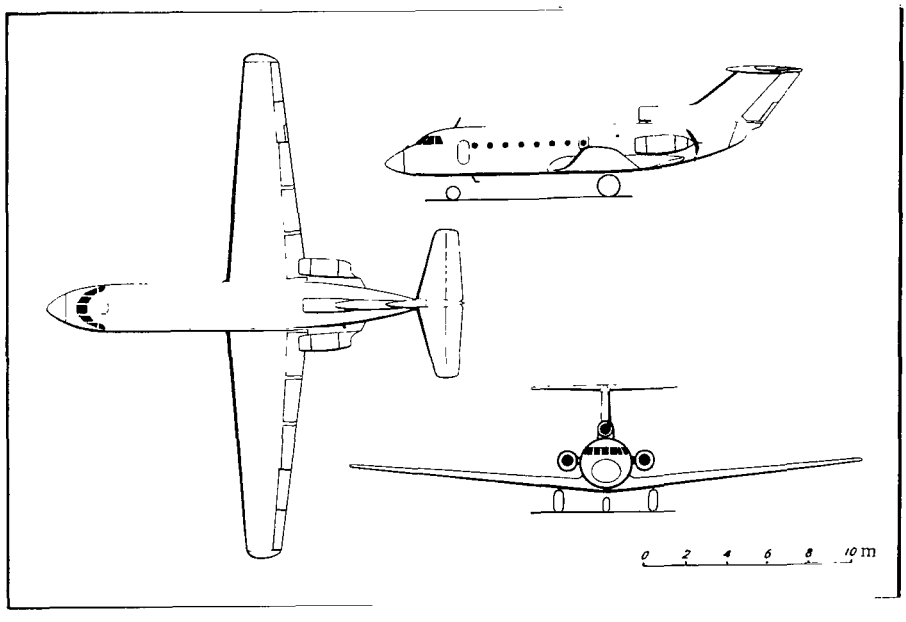


Passenger aircraft Tu-134, 1964.



Passenger aircraft Il-62, 1963.





Passenger aircraft Yak-40. 1967.

10. THE SCHOOL OF SOVIET AIRCRAFT DESIGNERS

The Soviet school of aircraft design combines simplicity and boldness of engineering and design thinking with high scientific quality and inventiveness.

Soviet aircraft designers react quickly to everyday requirements, yet they also take a long-range view.

Their characteristic features are rational designing with a view to the environmental requirements and a sober view of the economic and material potential of the country.

The successes attained by the Soviet Union in rocket engineering and space exploration are closely related to the development of aviation.

Aircraft and rocket designers, mutually profiting from their scientific and technical experience, work together in strengthening the economic power and defense capability of the Soviet Union.

When the fiftieth anniversary of Soviet power was celebrated, the aircraft industry of the USSR had achieved worldwide recognition. Its scientific and technical forces and production potential had withstood with honor the most difficult of all tests during World War II and new trials and tribulations in the postwar period.

However, almost the greatest achievement of the Soviet Union in aviation is the training of scientists, designers, engineers and skilled workers in aircraft and engine construction — the creation of the Soviet school of aircraft construction.

The enormous advance by the Soviet aircraft industry within three or four decades, its successes, were achieved both by the design offices and by the research institutes TsAGI, TsIAM, VIAM, LII and others, which blazed the trail in aviation science. The scientists, who continued the work of N. E. Joukowski and S. A. Chaplygin, advanced Soviet aviation science and helped develop aircraft construction in the Soviet Union, are rightly accorded authority and respect by the country.

A characteristic feature of the Soviet school of aircraft construction is its firm theoretical foundation, bold-design thinking infused with a spirit of constant innovation, the development of ideas with a long-range view in mind of scientific and technical progress of aviation and fields connected with it, utilization of the achievements in creating new materials and new techniques revolutionizing production processes. Concerning construction of military aircraft, Soviet designers take into account strategic factors based on modern military doctrine and the economic potential of the country.

How mature the Soviet school of aircraft construction is was demonstrated during the war.

During the mid-thirties, when the arms race and the aggravation of the international situation indicated that war was inevitable, competition between the designers in the large countries, especially Germany, the USSR, Britain, the United States, Italy and France increased greatly.

It was obvious that the coming war would be a war of engines, and victory would be on the side of those whose technology was on a higher level, where scientific and technical thinking was best.

At the beginning of World War II aviation was assigned the role of one of the decisive arms. A strenuous competition between countries occurred in scientific institutes, design offices, laboratories, and proving grounds. To be prepared for war, to overtake the enemy in technical development, this became the main aim of every Soviet designer, no matter in which field of armament he worked.

Since every country kept its arms production secret, it was difficult if not impossible to predict everything. Nevertheless, when the German army attacked the Soviet Union and the main forces of the Luftwaffe began operating, it became clear that Soviet aviators had been thinking correctly.

As mentioned before, at the time of the outbreak of war the Soviet Union tested and put into serial production the fighters MiG-3, LaGG-3, and Yak-1, the attack plane Il-2 and the bomber Il-4, light bombers Pe-2, and heavy bombers Pe-8.

During the war some types of aircraft were dropped as unsuitable; others, on the contrary, were introduced into the air force. For instance, production of MiG-3 fighters was discontinued in October 1941, then the Pe-8 bomber went out of production, and in 1943 the Il-4 bomber. In 1944 new Tu-2 bombers began reaching the front.

The main aircraft with which Soviet pilots fought throughout the war, from the very beginning until final victory, were the Yakovlevs and Lavochkins (fighters) and Ilyushins and Petlyakovs (attack planes and bombers).

In the aerial fighting we were able to gain detailed knowledge about the enemy's planes. Soviet designers knew well the strong and the weak points of German aviation. They understood in which direction the creative minds of their designers would work, and they endeavored to prevent the possibility of German surprises. "A designer has to look forward." This was the main motto of Soviet designers during the war.

This knowledge of the enemy's armaments and the ability to predict their further development enabled the Soviet designers to ensure qualitative superiority to aviation, tanks, artillery.

Soviet designers always kept in mind that a designer must also be a tactician, that he must know perfectly all the peculiarities of his armament and must even be able to suggest the most effective application of new weapons in combat. A well-known aircraft or tank or gun may be improved in such a way that it requires completely different tactics. During the course of the war, new weapons often change some tactical principle that had been followed for years.

During the war the designers observed attentively how their work was assessed at the front. The designer's interest in a machine was not exhausted as soon as the prototype is was ready. His duty was to observe his creation from the moment it took shape until it entered the battlefied, to correct quickly any defects and to perfect the machine. The designers also watched how the enemy reacted in combat to their weapons. It was important to them to discover quickly the weak points in their designs and to remedy them. This was achieved by close cooperation between designers and the frontline. The greatest danger for a designer is isolation from life, from the frontline, when he thinks that he has attained his ideal and disregards the fact that the enemy ceaselessly improves his armaments and also tries to foresee what he may expect from our side.

When designing a new aircraft, every designer considers not only its combat qualities and tactics but also its technical and economic aspects. Great discretion is required in selecting material for machines. This problem has to be handled very carefully because in wartime some materials become extremely scarce. Some production or raw material base may be put out of action by enemy bombing or may simply remain in enemy-occupied territory. This is what happened in the beginning of World War II.

What unexpected difficulties may occur with material is shown by the example of the LaGG-3 fighter. Delta wood was chosen as the main structural material for this aircraft. Compressed under high pressure and impregnated with phenolic resins, this wood was much stronger than pine which was usually used. As soon as war broke out, delta wood became extremely scarce, because the resins required for its impregnation were imported from abroad, and under wartime conditions deliveries were difficult to obtain. Also the types of wood required for making delta wood were scarce.

In the end a solution to the difficulties with delta wood was found. Its use in wartime would undoubtedly have been unprofitable. It was found in actual practice that aircraft made of amply available Siberian pine was equal to aircraft made of delta wood, both in weight and in technological properties.

Experience in World War II taught that not all prewar forecasts are proved correct in actual combat conditions.

Shortly before the war a high-speed, twin-engined reconnaissance aircraft with good aerodynamic qualities and streamlined shape, the Yak-4, was designed. Maximum speed of this plane, made almost entirely of wood, was nearly 150 kph faster than the speed of a high-speed bomber powered by the same engines. This was a temptation to change the Yak-4 reconnaissance plane into a short-range bomber. But when the plane was put into serial production, it was a disappointment. It was necessary to have a defensive cannon on a standard swiveling mounting with an unwieldy armor plate for protection of the gunner, and this impaired the streamlined shape and made the plane heavier. The experiment was not successful and in the end it was abandoned. The Yak-4 planes took almost no part in the war; at that time Petlyakov's dural dive-bomber Pe-2 had already successfully passed its tests and was being mass-produced.

Something similar happened with the MiG-3 fighter built at the beginning of 1940. Its designers, A. I. Mikoyan and M. I. Gurevich, had embodied in this machine all the achievements of aerodynamics available at that time. The plane was powered by Mikulin's AM-35A engine. Thus the MiG-3 was the fastest fighter; its maximum speed was 640 kph. It also had the highest ceiling of all fighters. This circumstance was considered very important.

The tactical doctrine of the late thirties was based on the assumption that aerial combat would take place at high altitudes. All countries endeavored to raise the ceiling of combat aircraft. The MiG-3 was the most pronounced expression of this doctrine. It had considerable advantages as compared with the Messerschmitt, not only in ceiling and speed but also in armament. It had five weapon emplacements whereas the Messerschmitt had three.

Soon after the outbreak of war, however, it was found that the German pilots flying Messerschmitts, which had a lower ceiling than the MiGs, did not fight at altitudes where they were at a disadvantage. Contrarily, they endeavored to enforce dogfights at low altitudes where the heavier MiGs

were less maneuverable. In addition, the range of the MiGs at low altitudes was also insufficient.

When all these circumstances became obvious, the designers of the MiG tried to reduce the weight of the plane by removing part of the armament and by some other measures. This was of no avail, and finally it was decided to discontinue production of MiG-3 planes.

These examples show that a fundamental mistake in technical policy leads eventually to failure, not to mention the waste of effort and material means.

There are also examples of the opposite, when planes were highly successful in war, although before the war they had been the source of controversies and doubts. This happened with the Il-2 attack plane.

Some military specialists at first did not fully appreciate the armored attack plane. They thought its armor was insufficient and its speed too low, that it would be a vulnerable target, and that therefore it would not find any application. This opinion was based on the assumption that aerial warfare would be conducted at great altitudes and that high ceiling and speed would be most important for aircraft in the coming war. Even after the Il-2 had been tested and the theoretical data had been confirmed, the aircraft was almost rejected. It passed the government test in January 1940, and almost up to the beginning of 1941 it stood motionless. Nearly a whole year was lost.

Ilyushin, being convinced of the quality of the attack plane, appealed to the Party Central Committee on 7 November 1940. It was decided to put the Il-2 immediately into serial production. Thanks to extraordinary measures the first two series-produced planes were ready as early as March 1941. In the course of the war the attitude toward the attack plane changed radically. The Il-2 became one of the most popular planes. Neither the Allies nor the Soviet Union's enemies had anything similar to the Il-2.

True, petty criticism of the plane continued even after war had broken out. The designer was forced to change this two-seater with defensive armament for protection against fighters attacking from the rear into a single-seater without such defensive armament, and all this for one purpose: to reduce the weight of the plane, to raise its ceiling and speed. However, at the peak of the fighting because of the large losses of single-seater attack planes the previous two-seater version was adopted again, with the establishment of a weapon emplacement so that the gunner-radio operator could fire at enemy fighters attacking from the rear.

The critics of the aircraft did not understand that one cannot fight tanks from high altitudes. Destruction of the tanks was more successful the lower the attack plane dived, and therefore it did not need high speed.

New technical means create new tactics. The Il-2 plane needed tactics corresponding to attack planes.

This is what life taught us.

It was not easy to learn these lessons. The creation of new aircraft and improvement of existing ones often called for technical risks, changes in one's personal creative plans, and what was most difficult, discarding old prejudices.

To improve a combat plane in wartime, alterations had to be done in a way so as not to impair output. It is tempting to make changes in design, but if these be done unrestrainedly it might reduce the output of the weapon. The designer must always take care not to introduce improvements that might jeopardize fulfillment of the plan.

The designers were therefore in close touch with serial production. Before they introduced an improvement of existing weapons they had to have a clear idea of the difficulties in the technological process that their improvement might cause. The designers had to effect their improvements such that they could be introduced into serial production with minimum losses in daily supply of planes to the front.

It should be noted that in this respect Soviet designers had a great responsibility and achieved notable successes.

The Soviet fighters which were serial produced in the East had better combat and flight characteristics than the German Me-109. However, at the beginning of 1942 an improved fighter, the Me-109G, appeared at the front. Like the previous Messerschmitts, it was powered by a Daimler-Benz engine, but a more powerful one. The speed of the Me-109G was somewhat higher than that of its predecessors.

The Government Defense Committee stipulated that ways must be found to increase the speed of Soviet fighters so as to establish full supremacy over the modernized Messerschmitts, without reducing output of fighters even by a single plane.

The solution to this problem was increased engine power.

At that time Klimov's design office had already designed the M-107 engine, which had also passed the bench tests and was much more powerful than the M-105P engine mounted in Yak fighters and Pe-2 bombers.

In May 1942 the Government Defense Committee discussed the problem of raising the speed of fighter planes. The People's Commissariat of Aircraft Industry proposed putting into serial production the new M-107 engine instead of the current M-105P.

The engine makers were decidedly in favor of replacing the M-105P by the M-107. Such a profound change in production, however, might have considerably reduced the output of fighters. It was to be expected that the M-107, being completely new, would also require lengthy adjustments to overcome initial flaws.

The change-over to the M-107 would have been disastrous for the output of fighters and light bombers Pe-2, and another solution was therefore adopted: to supercharge the M-105P at the expense of a somewhat lower ceiling. This had already been thoroughly flight-tested on Yaks and had yielded excellent results.

The fears of the engine specialists that boosting the M-105P could put too much of a strain on the engine and greatly reduce its service life proved groundless. In the bench test the supercharged M-105P engine lasted 203 hours whereas the service life of a series-produced engine was 100 hours. The engine was put into production under the designation M-105PF.

Thus within a short time the Soviet air force received fighters which had been considerably improved, yet serial production had not suffered the slightest drop in output. On the contrary, output greatly increased.

Saving time was an overriding consideration. Wherever there was a choice between introducing a completely new design and improving an existing one, preference was given to the latter course.

During the war designers and production engineers constantly improved weapons. For instance, in mid-1942 Yak and La fighters were to be provided with RS rocket missiles and then with mountings for suspending aerial bombs under the wings.

In 1942 an outstanding creation of artillery designers appeared: a large-caliber 37-mm aircraft cannon. Since it had to be mounted on aircraft, it was necessary to build a heavy cannon fighter.

Within record time the Yak-9T was built. This was the first Soviet fighter with heavy cannons. It successfully passed first the government tests and then the military tests and was put into large-scale production. Further work was done to increase the firing power of the fighter. Later it was fitted with a 45-mm cannon. Toward the end of the war an even larger cannon was mounted.

The war was a difficult test for Soviet designers, but its lessons were utilized to perfect the Soviet aircraft design school.

In recent years Soviet scientists and designers achieved grandiose results in rocketry. Artificial earth satellites, photographing the far side of the moon, a soft landing on the moon, accurate "landing" of an entire series of huge ballistic missiles in the Pacific, manned space flights — all this had only been a dream or even a utopia not long ago, and now it became reality.

Rocket engineering completed a gigantic step forward within a time that by the old standards would seem incredibly short. Its achievements are staggering.

At one time the successful development of space flights encouraged the opinion that aviation had outlived its usefulness.

"Will aviation survive in the future or will it be completely superseded by rockets?" This question was asked all over the world by many specialists who were engaged in aircraft or rocket construction. Life already answered the question.

In spite of the great attention given all over the world to rocket engineering and in spite of its enormous successes, experience in the recent past has shown that regardless of these successes in the present and in future, there are always fields of application of flying machines where rockets cannot supersede airplanes.

Today's aircraft will be replaced by other types. Rockets will compete with aviation and revolutionize it, but not destroy it.

Rockets have a broad field of application. First of all there is space, interplanetary communication which by now is obviously a realistic proposition. Then there are research flights both deep into space and around the earth for astronomical, geographical, biological and other research purposes.

Intercontinental ballistic missiles, which accurately reach their target, are weapons of previously unheard-of power. Nevertheless, rockets cannot always replace airplanes. Judging by frequent pronouncements, military specialists in many countries believe that as long as there are ground forces, they will need such tactical aviation as short-range fighters, short-range bombers and reconnaissance planes of all types.

It is true that some people believe that the work of reconnaissance planes may be done by automatic reconnaissance rockets. Is that not exaggerated? After all, aerial reconnaissance must be carried out by man equipped with modern optical and radio equipment. This applies to fixed targets such as towns, ports, railroad junctions, and even more so to mobile targets.

Some non-Soviet writers have a mania for robots. Some aggressive generals dream of a push-button war in which they would not need any

soldiers who are sometimes unreliable. These ideas are the ideological source of military doctrines which lower the role of man in military strategy.

The Americans believe that the reliability of rockets is fifty percent, that out of ten rockets only five reach their target with certainty. *

Manned aircraft ensure greater accuracy, but this accuracy is not very important in the case of nuclear weapons with their enormous damage radius of tens of kilometers.

Some theoreticians believe that under conditions of nuclear warfare, large losses in aviation are acceptable. For instance, the French military specialist Rougeron says: "Of what importance is the loss of some hundreds of Stratojet and Stratofortress planes if some dozens of them will succeed in penetrating and dropping atom bombs equivalent to 20 million tons TNT on nuclear plants, stocks of nuclear armaments and launching sites for intercontinental missiles with an accuracy of which only manned aircraft are capable."

To Soviet military theory such a concept, built on the acquiescence to large-scale losses of pilots, is unacceptable. Rockets must completely supersede aircraft in areas of military application where they can fulfill their task more reliably and more economically. The most sober specialists are very careful in defining their attitude toward the question of plane or rocket.

For instance, the British Field Marshal Montgomery said that as far as can be foreseen, piloted aircraft will yet remain for a long time to come. They will be indispensable for reconnaissance and other tactical operations because the human brain is the only mechanism capable of functioning under unexpected circumstances.

The American General Lindsay, head of the planning bureau of the U. S. Army Air Force, said in one of his speeches that even after enemy territory has been subjected to attacks by strategic ballistic missiles, there still remains a considerable part of the means for aerial bombardment, bases for launching remote-controlled missiles, airfields dotted all over the country. Against these targets piloted aircraft will be used, being more maneuverable and accurate.

Military and technical considerations lead increasingly to approximately the following conclusions: with the appearance of long-range ballistic missiles the strategic bomber becomes less important than it was previously. Because missiles are less vulnerable than planes and their accuracy of hitting a target is now great, missiles can carry a nuclear charge of huge destructive power to the stipulated target more effectively than can a heavy bomber.

The most effective weapon against bombers of all kinds are anti-aircraft, ground-to-air missiles. However, if this weapon is to be used, the defended territory needs a certain density of these anti-aircraft missile launchers, because they have a comparatively small operational range.

* For instance, General Shriver, head of research and development in the U.S. Ministry of Aviation, said in the House of Representatives, obviously on the basis of unsuccessful rocket launchings from Cape Kennedy, that since rocket systems "...work within very small tolerances and have a mass of pipes, valves, etc., many small components may fail. And it is usually the little things that fail." [Retranslated from Russian]. For instance, the famous American Atlas rocket, a 26-meter missile, consists of 300,000 components. Each of them may become the source of failure and foil the mission of the flight.

Many specialists agree that tactical aircraft used in short-range fighting, aerial photographic, and radio reconnaissance, for cooperation with ground forces and also for subduing enemy aircraft over territory insufficiently supplied with anti-aircraft missile launchers, will for a long time yet remain part of the air forces of all countries.

Military planes capable of independently solving tactical tasks will be armed, in addition to firearms, with missiles for various purposes, air-to-air, air-to-ground, air-to-ship and others.

So far we have discussed military applications of aviation. This cannot be avoided as long as there are reactionary forces in the world planning war and aggression and resisting the endeavor of the nations to achieve disarmament.

Aviation has an equally great future in the peaceful life of mankind. It has a leading role in air transport. All kinds of aircraft have still to be vigorously developed, beginning with gigantic transcontinental jet liners and ending with tiny piston-engined passenger planes, including ambulance and agricultural aircraft, serving in the most diverse fields of the economy and other fields of human activity. Here aviation is fated to be the only form of aerial transport for a long time to come. This transport has to develop and improve constantly.

Many projects of aircraft of the future are now being widely publicized in the world press. This indicates that designers the world over are busy solving new problems of civil aviation.

Scientists and engineers are engaged in creating large transport and passenger planes for transcontinental flights, able to develop a speed two or three times the speed of sound.

This is a very complicated problem. To achieve this aim, various problems must be solved in engine construction, fuel, materials; above all the thermodynamic barrier must be overcome. The designers, therefore, have not only to ensure normal conditions for passengers and crews, but also they must solve the problem of finding structural materials whose strength would not be affected by the high temperature to which the surface is subjected.

Increased flying speed of large transport planes will increasingly erase the difference between conventional aircraft and winged missiles.

As is well known, modern aircraft require large and specially equipped airfields with expensive runways several kilometers long. In many countries designers are engaged in devising aircraft which can take off and land vertically. This problem will undoubtedly be solved one day, and that will again influence the further development of military and civil aviation. Then there will not be any need for special airfields. Modern high-speed aircraft will then be able to reach the remotest corners of the earth.

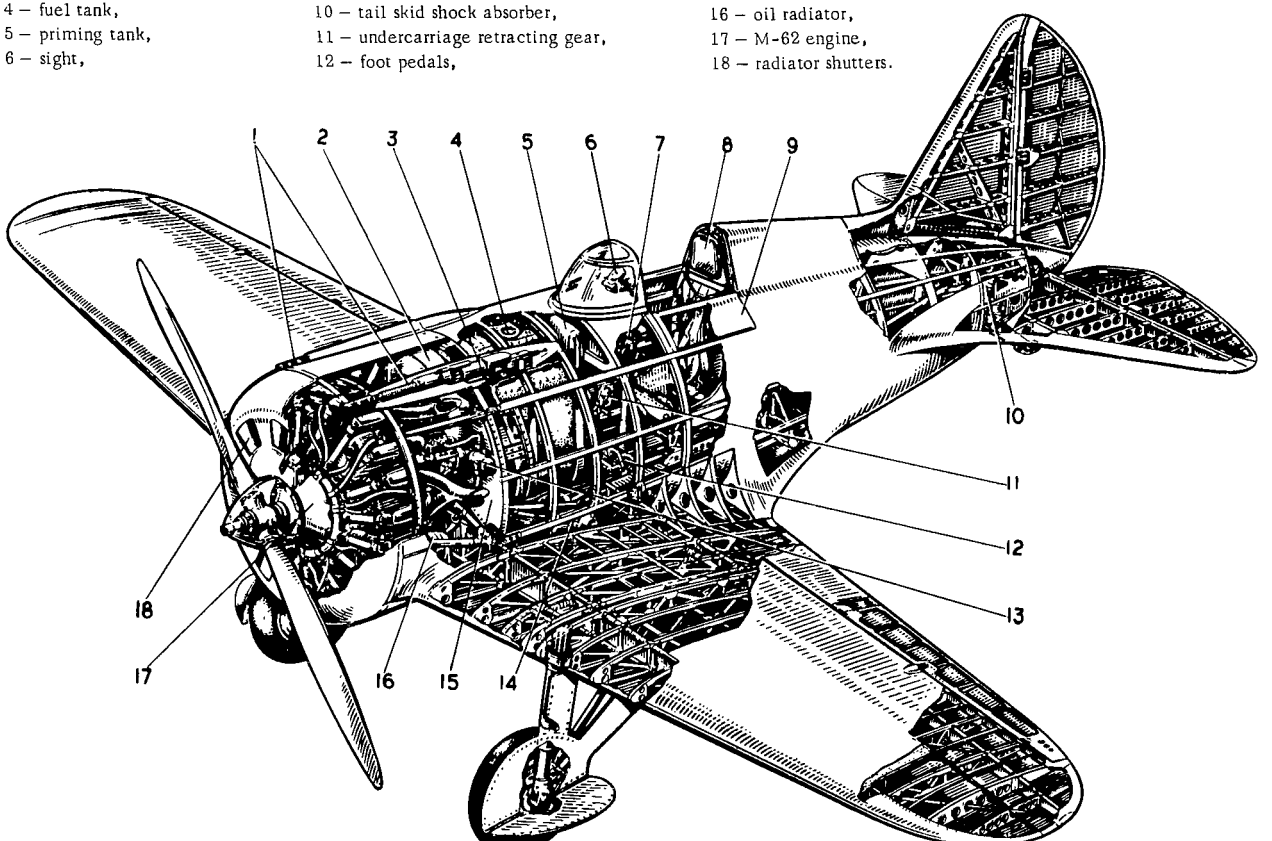
The most topical problem, both for the future and the present, is the development of radio instruments, ground and airborne, permitting transport planes to be literally independent of weather conditions so that they can safely take off and land under any weather conditions and in the worst visibility.

Finally, there is the creation of a variety of economical small planes being used for local airlines under conditions off the airfield. Such planes — simple, light, cheap, not requiring runways, reliable — will in peacetime take the place of the automobile in the nations' life.

Rocket engineering, which itself developed on the basis of many years' experience and achievements of aviation science and technology, created by people who were educated by the Soviet school of aircraft construction, will in its turn boost further progress of aviation and will initiate methods of producing higher speeds and greater altitudes of flight.

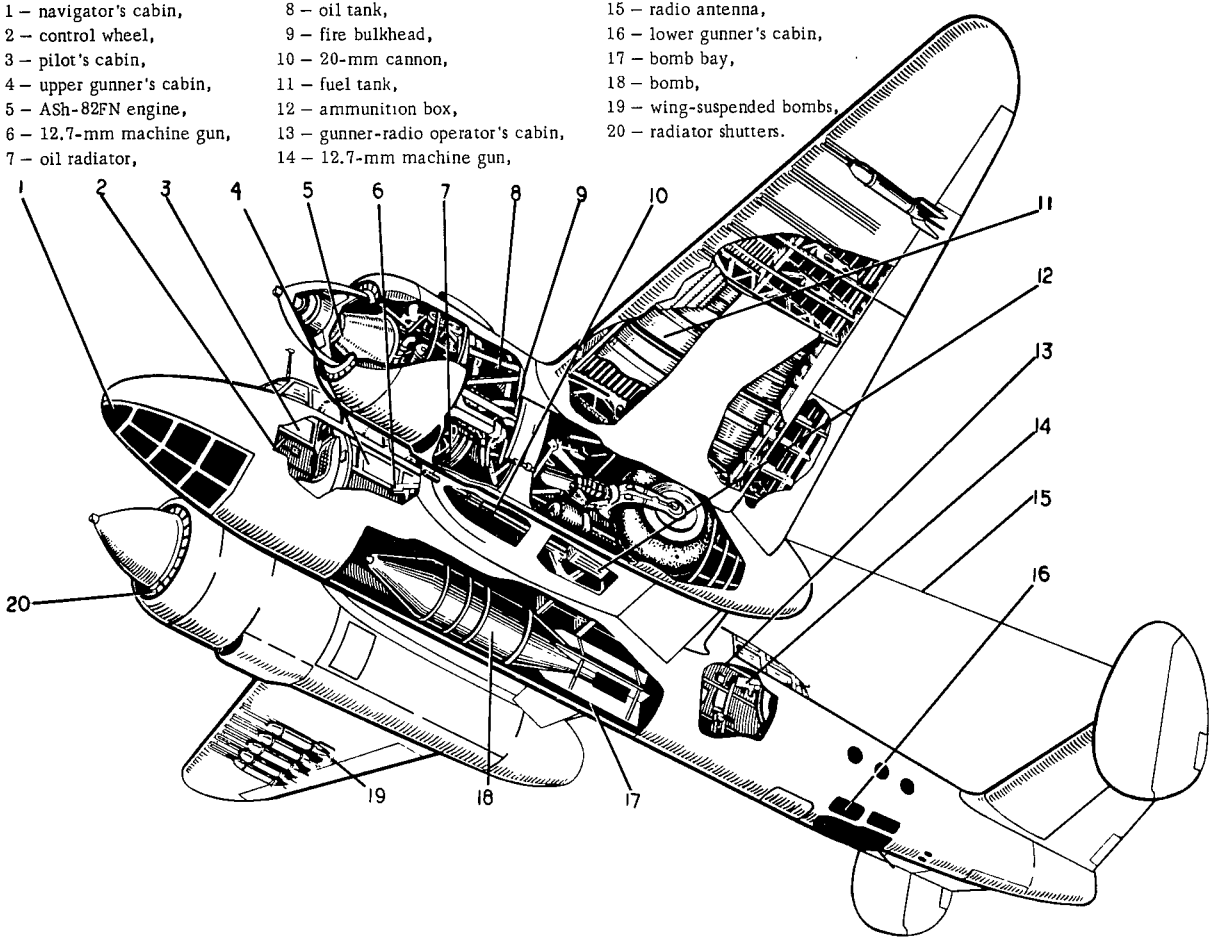
The fiftieth anniversary of the October revolution finds the Soviet aircraft builders full of strength and creative plans whose realization will strengthen even more the economic and defense potential of the Soviet Union.

1 – 7.62-mm machine guns,
2 – oil tank,
3 – ammunition box,
4 – fuel tank,
5 – priming tank,
6 – sight,
7 – joystick,
8 – head-rest,
9 – cockpit cowl,
10 – tail skid shock absorber,
11 – undercarriage retracting gear,
12 – foot pedals,
13 – oil filter,
14 – landing gear recess,
15 – fire bulkhead,
16 – oil radiator,
17 – M-62 engine,
18 – radiator shutters.



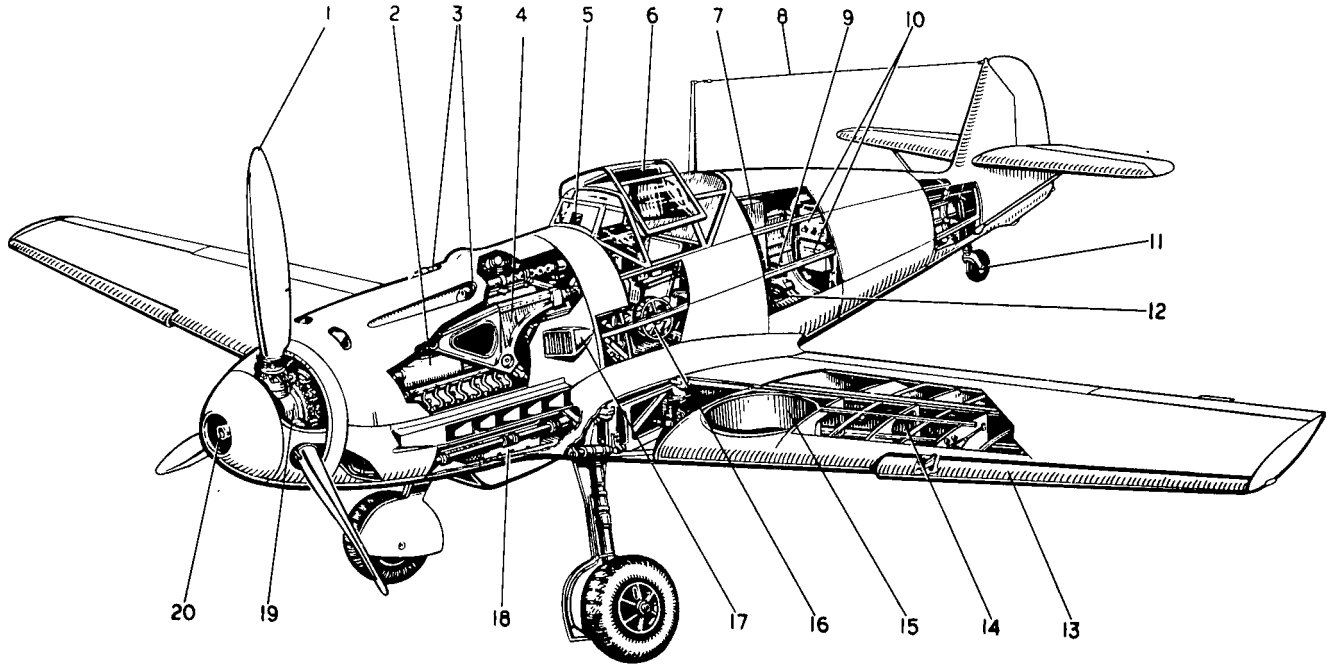
I. Fighter I-16

1 – navigator's cabin,
2 – control wheel,
3 – pilot's cabin,
4 – upper gunner's cabin,
5 – ASh-82FN engine,
6 – 12.7-mm machine gun,
7 – oil radiator,
8 – oil tank,
9 – fire bulkhead,
10 – 20-mm cannon,
11 – fuel tank,
12 – ammunition box,
13 – gunner-radio operator's cabin,
14 – 12.7-mm machine gun,
15 – radio antenna,
16 – lower gunner's cabin,
17 – bomb bay,
18 – bomb,
19 – wing-suspended bombs,
20 – radiator shutters.



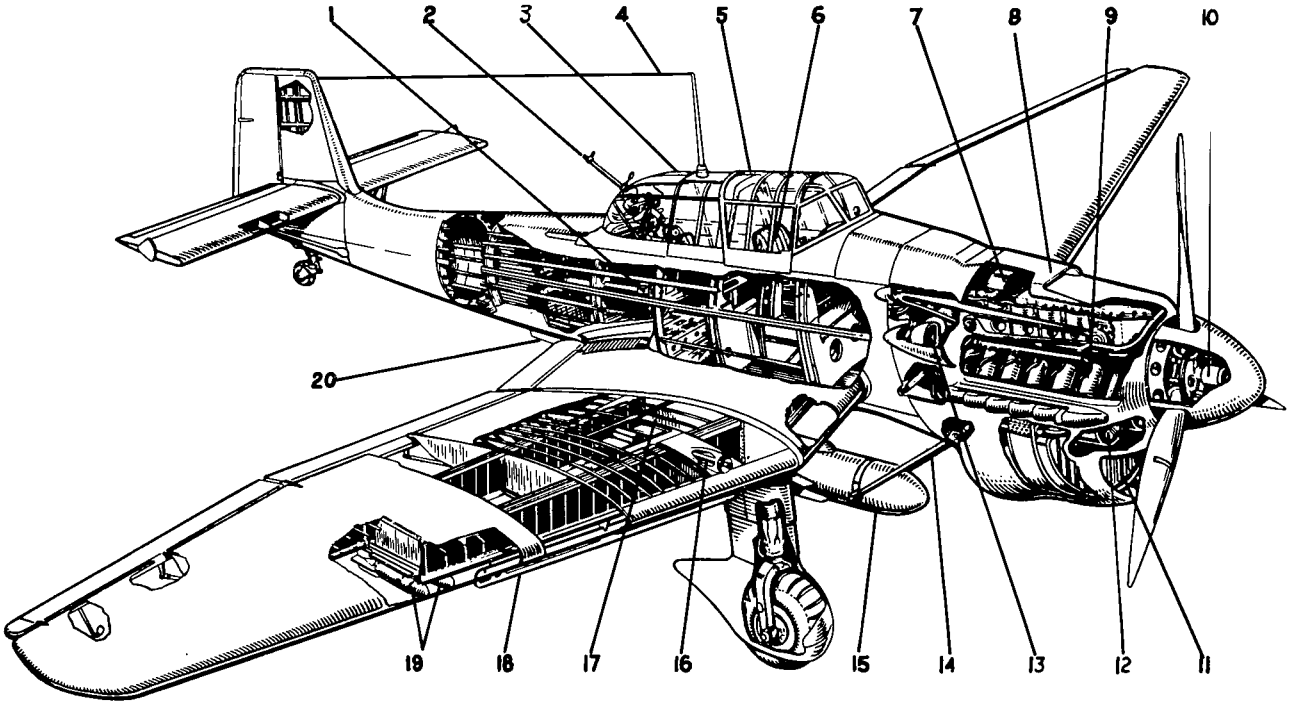
II. Bomber Tu-2

1 – controllable-pitch propeller,
2 – DB-601 engine,
3 – 7.92-mm machine guns,
4 – engine mounting,
5 – sight,
6 – protective armor,
7 – fuel tank,
8 – radio antenna,
9 – air cylinder,
10 – radio,
11 – retractable tail wheel,
12 – oxygen container,
13 – controllable slat,
14 – fuel tank,
15 – landing gear recess,
16 – trim tab control wheels,
17 – oil radiator,
18 – water radiator,
19 – reduction gear,
20 – 20-mm cannon.



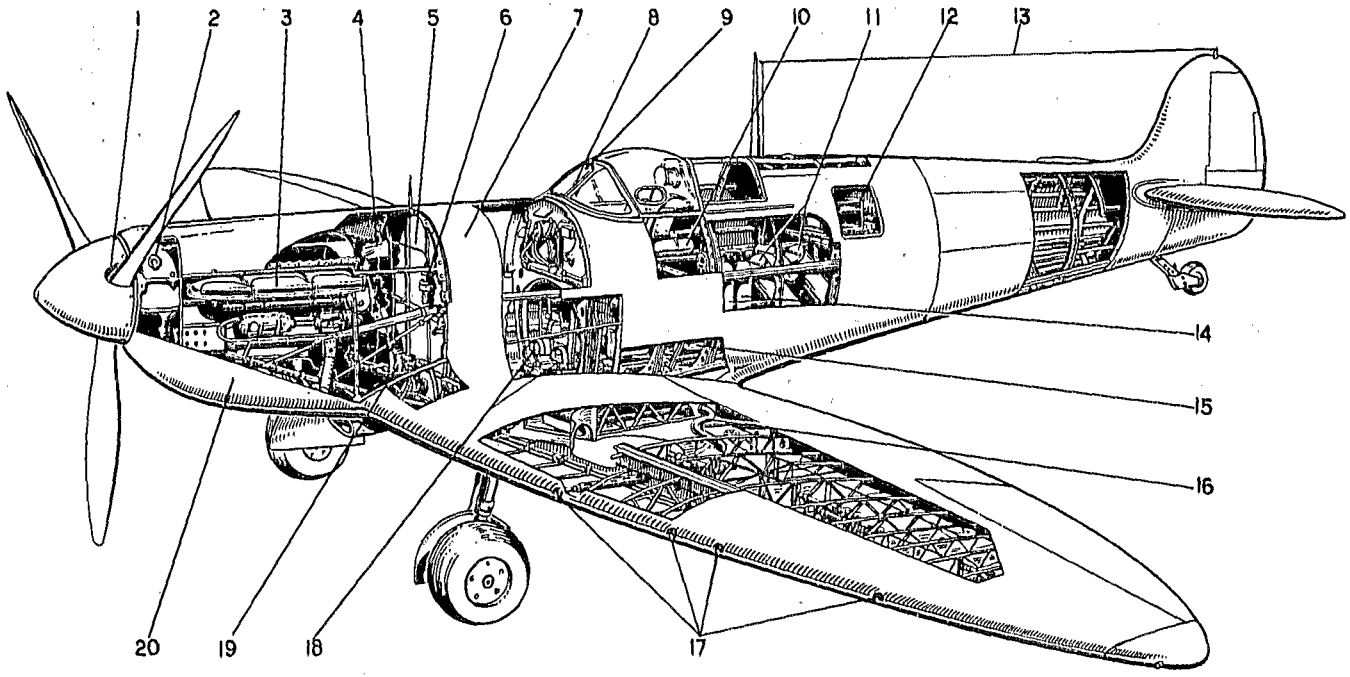
III. Fighter Me-109

1 – gunner's seat,
2 – 7.92-mm machine gun,
3 – gunner's hood,
4 – radio antenna,
5 – sliding canopy,
6 – pilot's seat,
7 – oil radiator,
8 – air intake
9 – Jumo-211 engine,
10 – controllable-pitch propeller,
11 – water radiator,
12 – fuel-injection pump,
13 – air intake of the supercharger,
14 – carrier,
15 – bomb,
16 – 7.92-mm machine gun
17 – fuel tank
18 – drag brake,
19 – bombs
20 – photographic camera.



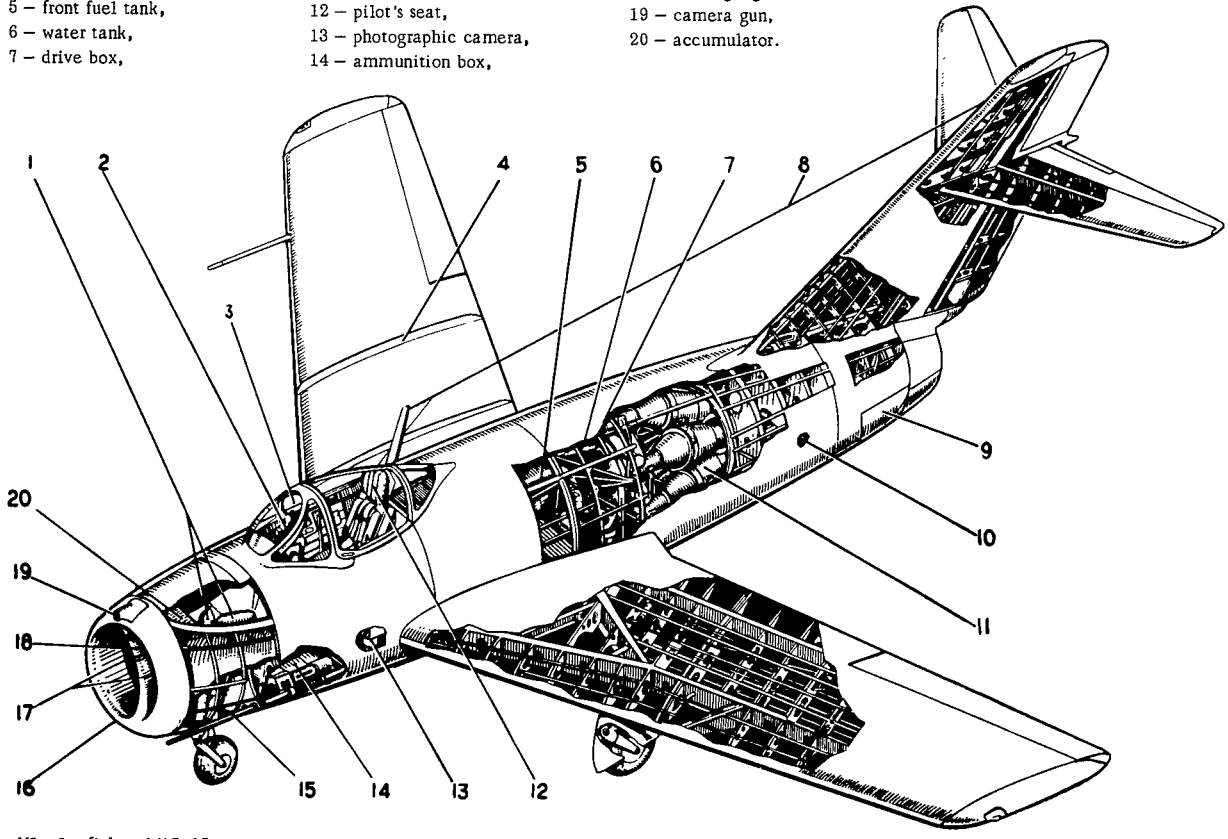
IV. Dive-bomber Ju-87

1 – controllable-pitch propeller,
2 – glycol tank,
3 – Merlin engine,
4 – separator tank,
5 – fire bulkhead,
6 – oil filter,
7 – fuel tank,
8 – sight,
9 – bulletproof glass,
10 – oxygen container,
11 – illuminating flares,
12 – radio,
13 – radio antenna,
14 – air cylinders,
15 – accumulator,
16 – tube for heating machine guns,
17 – 7,69-mm machine guns,
18 – pedals,
19 – fuel filter,
20 – oil tank.



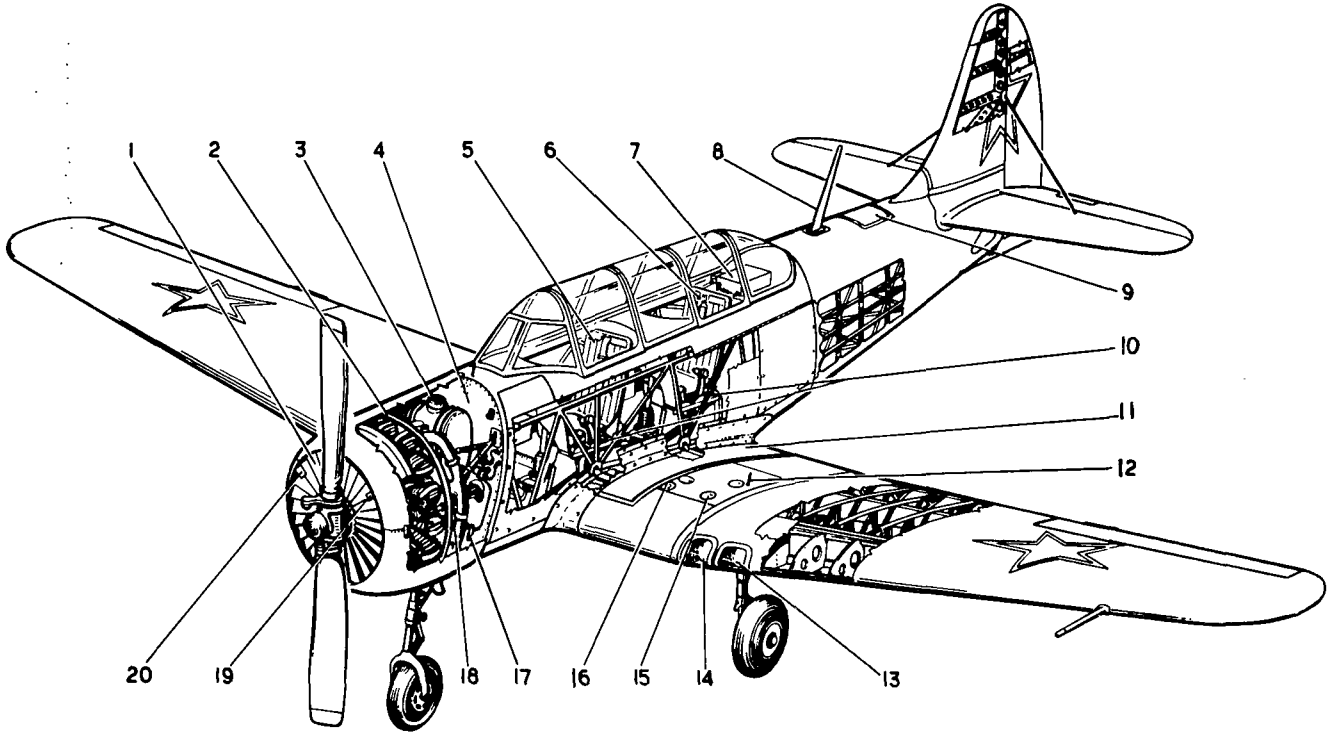
V. Fighter Spitfire

1 – oxygen containers,
2 – sight,
3 – bulletproof glass,
4 – boundary layer fence,
5 – front fuel tank,
6 – water tank,
7 – drive box,
8 – radio antenna,
9 – drag brake,
10 – rear fuel tank,
11 – RD-45F jet engine,
12 – pilot's seat,
13 – photographic camera,
14 – ammunition box,
15 – 23-mm cannon,
16 – 37-mm cannon,
17 – air ducts,
18 – landing light,
19 – camera gun,
20 – accumulator.



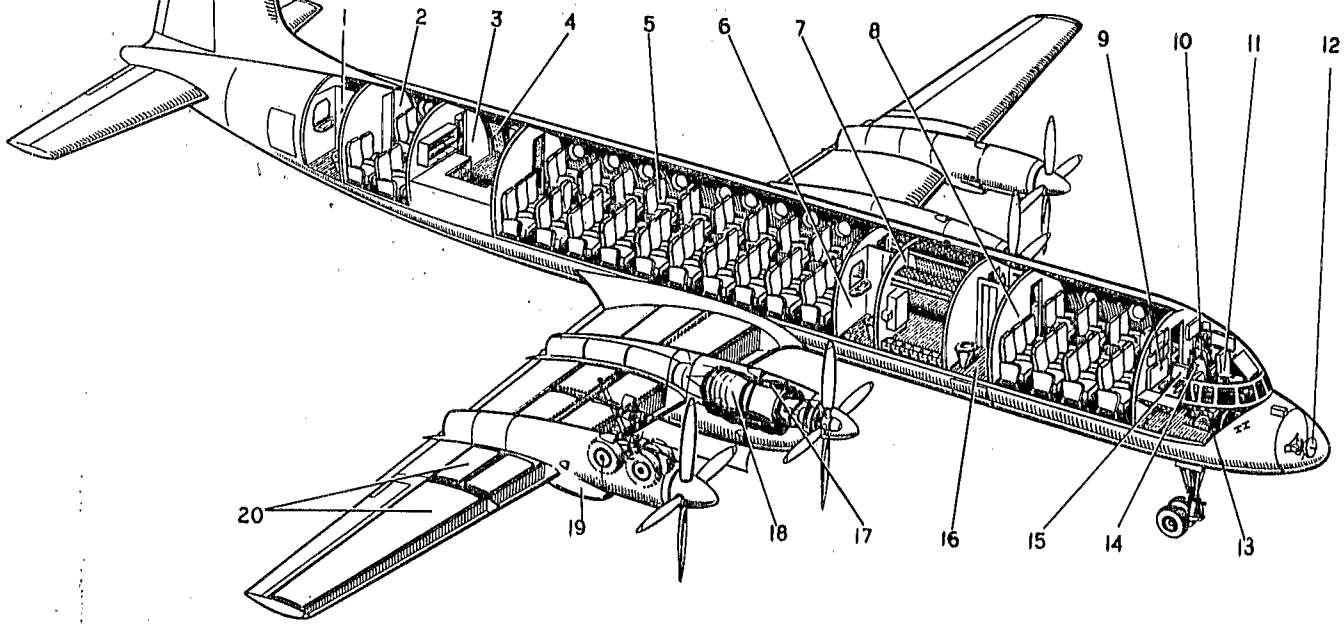
VI. Jet fighter MiG-15

1 – radiator shutters,
2 – AI-14R engine,
3 – oil tank,
4 – fire bulkhead,
5 – instructor's seat,
6 – pupil's seat,
7 – radio compass receiver,
8 – radio antenna,
9 – radio compass antenna,
10 – instrument panels,
11 – walkway,
12 – landing gear warning device,
13 – landing light,
14 – navigation light,
15 – fuel tank filler neck,
16 – fuel gauge,
17 – air filter,
18 – exhaust manifold,
19 – air intake of generator ventilation,
20 – air intake of cabin heating.



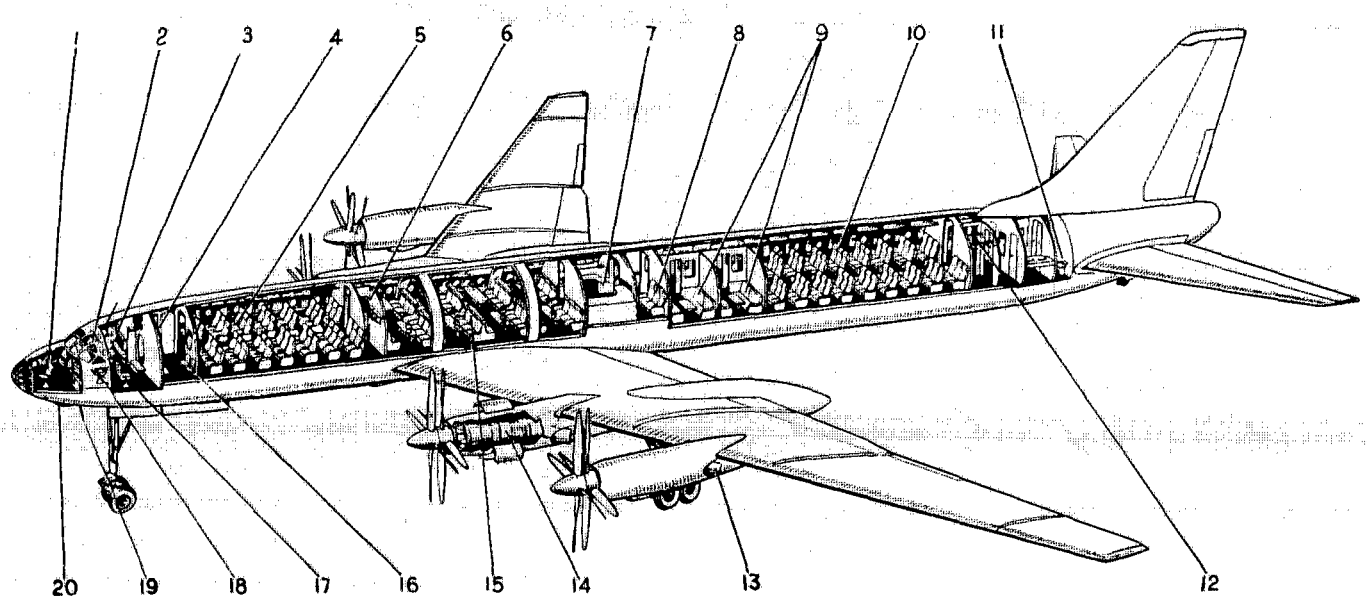
VII. Two-seater training aircraft Yak-18A

1 — toilet,
2 — rear compartment,
3 — snack bar,
4 — entrance door,
5 — main compartment,
6 — toilet,
7 — cloak-room,
8 — front compartment,
9 — radio equipment,
10 — navigator's place,
11 — captain's place,
12 — radar,
13 — second pilot's place,
14 — flight engineer's place,
15 — radio operator's place,
16 — toilet,
17 — electric starter,
18 — AI-20 engine,
19 — oil radiator,
20 — fuel tanks,



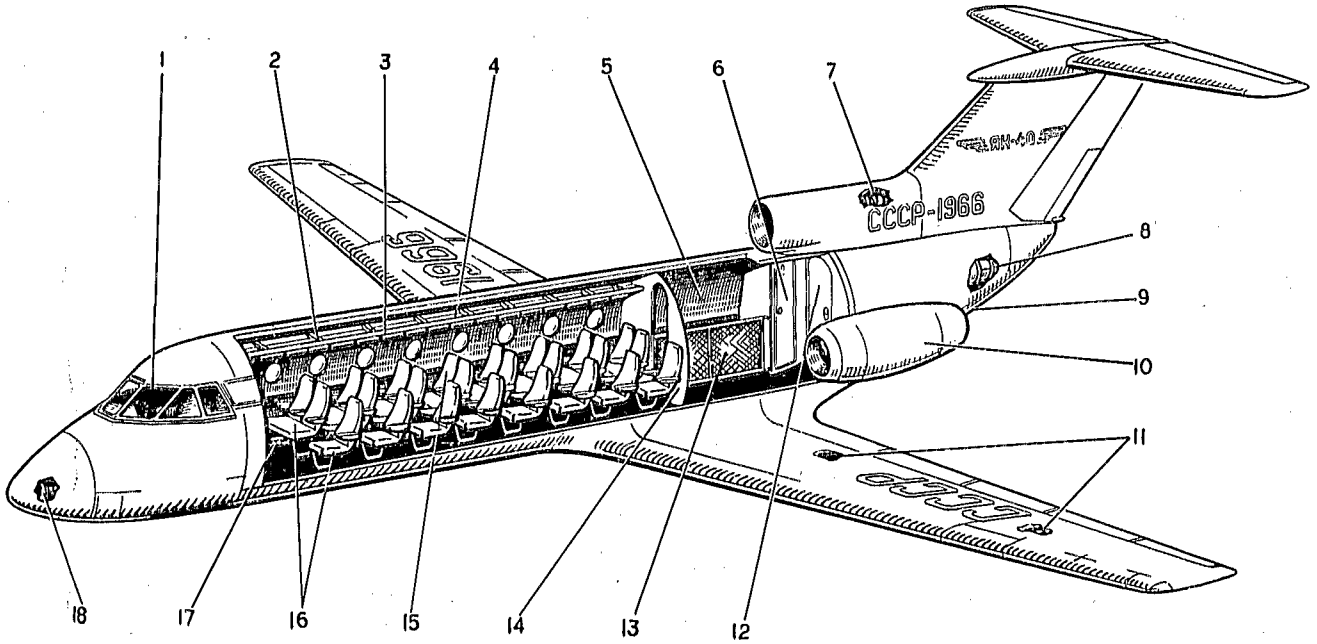
VIII. Turboprop passenger aircraft Il-18

1 – navigator's place,
2 – second pilot's place,
3 – radio operator's place,
4 – toilet,
5 – front compartment,
6 – cloak-room,
7 – snack bar,
8 – crew's compartment,
9 – sleeper compartment,
10 – rear compartment,
11 – toilet,
12 – cloak-room,
13 – exhaust pipe,
14 – NK-12 turboprop engine,
15 – central compartment,
16 – stewardesses' station,
17 – flight engineer's place,
18 – captain's place,
19 – radio antenna,
20 – weather radar.



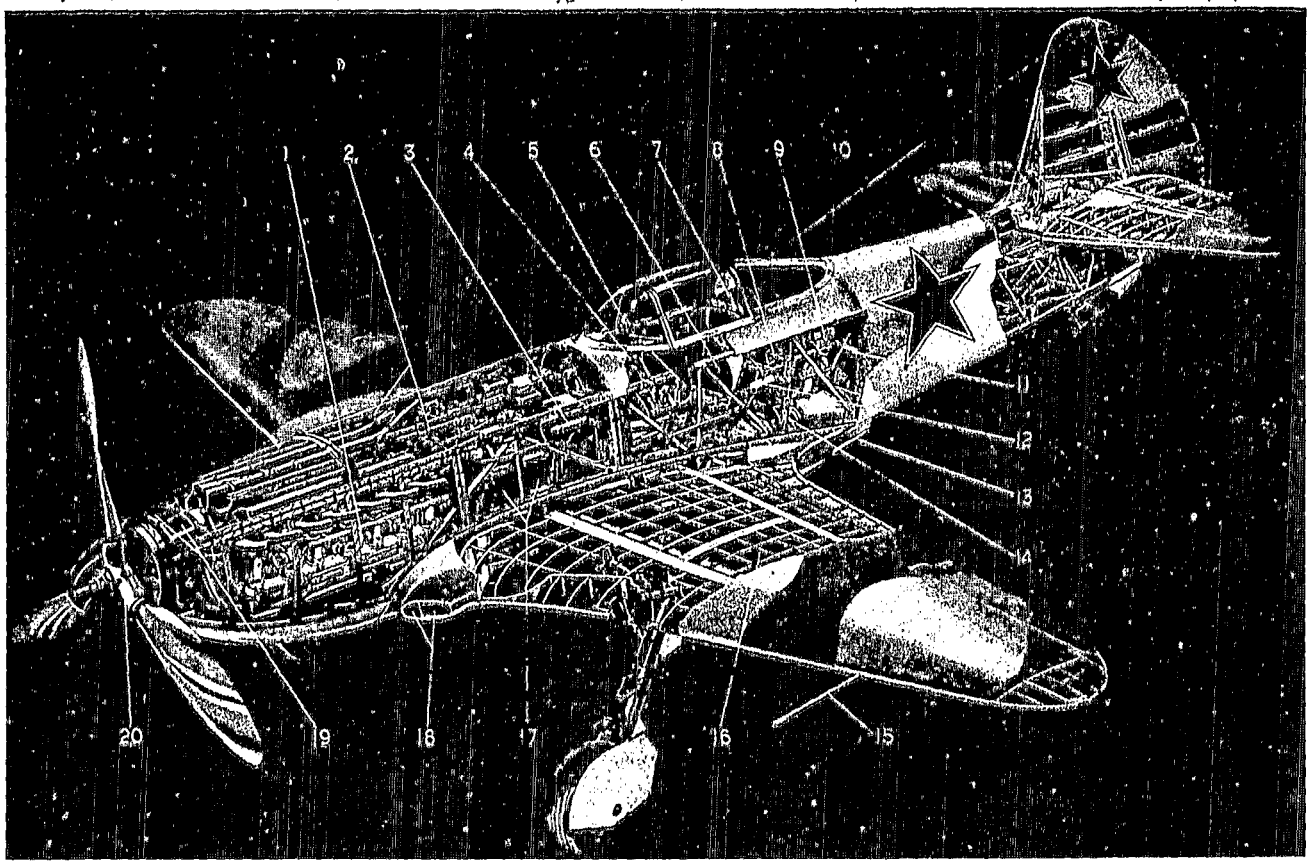
IX. Turboprop passenger plane Tu-114

1 – pilot's cabin,
2 – ventilation valves,
3 – ceiling,
4 – rack,
5 – cloak-room,
6 – toilet,
7 – turbine starter,
8 – center engine AI-25,
9 – entrance,
10 – lateral engine AI-25,
11 – fuel tanks,
12 – entrance door,
13 – luggage compartment,
14 – removable partition,
15 – passenger compartment,
16 – folding seats,
17 – air conditioner vent,
18 – weather radar.



X. Passenger jet plane Yak-40

1 — VK-105PF2 engine,
2 — 20-mm cannons,
3 — supercharger bottle,
4 — joystick,
5 — sight,
6 — armored backrest,
7 — bulletproof glass,
8 — radio,
9 — accumulator,
10 — radio antenna,
11 — air cylinder,
12 — oxygen container,
13 — water radiator shutter,
14 — water radiator,
15 — pitot-static tube,
16 — fuel tank,
17 — ammunition boxes,
18 — radiator air intakes,
19 — water tanks,
20 — controllable-pitch propeller.



XI. Fighter Yak-3

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Designations

Aircraft Engines

Non-Soviet Engine Designations

Name Index

LIST OF ABBREVIATIONS APPEARING IN TEXT

Abbreviation	Transliteration	Translation
DOSAAF	Vsesoyuznoe Dobrovl'noe Obshchestvo Sodeistviya Armii, Aviatsii, i Flotu	All-Union Voluntary Society for Cooperation with the Army, Air Force, and Navy
GUGVF	Glavnoe Upravlenie Grazhdanskogo Vozdushnogo Flota	Main Administration of Civil Aviation
LII	Leningradskii Industrial'nyi Institut	Leningrad Industrial Institute
ODVF	Obshchestvo Druzei Vozdushnogo Flota	Society of Friends of the Air Fleet
TsAGI	Tsentral'nyi Aerogidrodinamicheskii Institut	Central Aerodynamic Institute
TsIAM	Tsentral'nyi Nauchno-Issledovatel'skii Institut Aviamotorostroeniya	Central Institute of Aircraft Engine Construction
VKP(b)	Vsesoyuznaya Kommunisticheskaya Partiya	All-Union Communist Party (Bolsheviks)

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